US Army Corps
of Engineers®
Walla Walla District

DRAFT

Lower Snake River Juvenile Salmon Migration Feasibility Report/ Environmental Impact Statement

December 1999

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	December 17, 1999	Draft 17 Dec 99 - 31 Apr 00

4. TITLE AND SUBTITLE	5. FUNDING NUMBERS
Lower Snake River Juvenile Salmon Migration Feasibility Report and Environmental Impact Statement (Draft FR/EIS)	
6. AUTHOR(S) US Army Corps of Engineers, Walla Walla District	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) US Army Corps of Engineers, Walla Walla District	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) US Army Corps of Engineers, Walla Walla District	10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

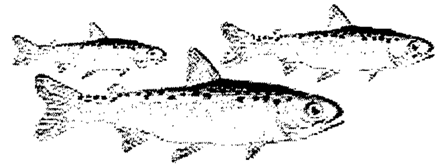
12a. DISTRIBUTION AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE
Public Comment period began 17 Dec 99 and ended 30 Apr 00. Approved for public release; distribution is unlimited	

13. ABSTRACT *(Maximum 200 words)*

The Corps of Engineers along with the Bonneville Power Administration, US Environmental Protection Agency, and US Bureau of Reclamation as cooperating agencies, analyzed four general alternatives intended to provide information on the technical, environmental, and economic effects of actions related to improving juvenile salmon passage. The four alternatives include Alternative 1 - Existing Conditions (the no-action alternative) and three different ways to further improve juvenile salmon passage. The action alternatives are: Alternative 2 - Maximum Transport of Juvenile Salmon, Alternative 3 - Major System Improvements, and Alternative 4 - Dam Breaching. Comparison of the alternatives by all of the factors assessed in the study has not offered a clear-cut recommendation at this time. It is the Corps of Engineer's intent to recommend a preferred plan of action in the Final FR/EIS.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Lower Snake River Project Endangered Species Act Fish Passage	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL



Lower Snake River Juvenile Salmon Migration Draft Feasibility Report and Environmental Impact Statement (Draft FR/EIS)

Lead Agency:	Department of the Army Walla Walla District Corps of Engineers 201 North Third Avenue Walla Walla, WA 99362-1876
For further information contact:	Lonnie Mettler Lead Planner Department of the Army Walla Walla District, Corps of Engineers Walla Walla, WA 99362-1876 (509) 527-7268

Comments must be received:	The official closing date for the receipt of comments is 31 March 2000.
Abstract:	Public comments are sought on this draft FR/EIS.

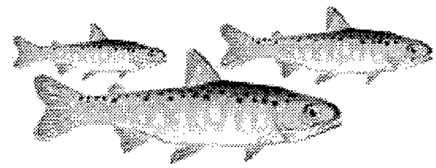
The Corps of Engineers along with the Bonneville Power Administration, U.S. Environmental Protection Agency, and U.S. Bureau of Reclamation as cooperating agencies, analyzed four general alternatives intended to provide information on the technical, environmental, and economic effects of actions related to improving juvenile salmon passage. The four alternatives include Alternative 1—Existing Conditions (the no-action alternative) and three different ways to further improve juvenile salmon passage. The action alternatives are: Alternative 2—Maximum Transport of Juvenile Salmon, Alternative 3—Major System Improvements, and Alternative 4—Dam Breaching. Comparison of the alternatives by all of the factors assessed in the study has not offered a clear-cut recommendation at this time. It is the Corps of Engineer's intent to recommend a preferred plan of action in the Final FR/EIS.

Lower Snake River Juvenile Salmon
Migration Feasibility Study

Draft Feasibility Report/
Environmental Impact Statement

December 1999

\\61443\WALLA WALLA\1346\DEIS\COVER.DOC



Contents

Figures

Tables

Acronyms and Abbreviations

λ	(lambda) population growth rate
°F	degrees Fahrenheit
$\mu g/m^3$	micrograms per cubic meter
AAQS	ambient air quality standards
ACHP	Advisory Council on Historic Preservation
AIRFA	American Indian Religious Freedom Act
AMPA	aminomethylphosphoric acid
aMW	average megawatt
ARPA	Archaeological Resources Protection Act
BA	Biological Assessment
BGS	behavioral guidance structure
BIA	Bureau of Indian Affairs
BKD	bacterial kidney disease
BLM	Bureau of Land Management
BNSF	Burlington Northern – Santa Fe Railroad
BOD	biochemical oxygen demand
BOR	U.S. Bureau of Reclamation
BOT	Board of Trustees
BP	before present
BPA	Bonneville Power Administration
BSM	Bayesian Simulation Model
CAA	Clean Air Act
CBFWA	Columbia River Fish and Wildlife Authority
CCAP	U.S. Climate Change Action Plan
CEAA	Canadian Entitlement Allocation Agreement
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CEQ	Council on Environmental Quality
CFC	chlorofluorocarbons
CFR	Code of Federal Regulations
cfs	cubic feet per second
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
Comp Plan	Lower Snake River Fish and Wildlife Compensation Plan
Corps	U.S. Army Corps of Engineers

Acronyms and Abbreviations (continued)

CR	County Road
CRI	Cumulative Rish Initiative
CRBG	Columbia River Basalt Group
CRMP	Cultural Resources Management Plan
CRFMP	Columbia River Fish Mitigation Program
CRITFC	Columbia River Intertribal Fish Commission
CSPE	Columbia Storage Power Exchange
CTCIR	Confederated Tribes of the Colville Indian Reservation
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CWA	Clean Water Act
DO	dissolved oxygen
DREW	Drawdown Regional Economic Workgroup
DREW HIT	Drawdown Regional Economic Workgroup Hydropower Impact Team
DSI	direct service industries
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESBS	extended submerged bar screen
ESL	Endangered Species List
ESU	Evolutionarily Significant Unit
EWITS	Eastern Washington Intermodal Transportation Study
FCRPS	Federal Columbia River Power System
Feasibility Study	Lower Snake River Juvenile Salmon Migration Feasibility Study
FELCC	firm energy load-carrying capacity
FERC	Federal Energy Regulatory Commission
FGE	fish guidance efficiency
FIRFA	Federal Insecticide, Fungicide, and Rodenticide Act
FPC	Fish Passage Center
FPE	fish passage efficiency
FR	Federal Register
FR/EIS	Lower Snake River Juvenile Salmon Migration Study Feasibility Report and Environmental Impact Statement
ft/sec	feet per second
FWCA	Fish and Wildlife Coordination Act

Acronyms and Abbreviations (continued)

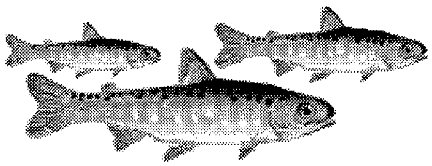
FWCAR	Fish and Wildlife Coordination Act Report
GBT	gas bubble trauma
GHG	greenhouse gas
GIS	geographic information system
GSA	General Services Administration
HCFC	partially halogenated fluorocarbons
HEP	Habitat Evaluation Procedure
HMU	habitat management unit
HU	habitat unit
HYDROSIM	Hydro Simulation Program
HYSSR	Hydro System Seasonal Regulation Program
ICBEMP	Interior Columbia Basin Ecosystem Management Project
IPP	Independent Power Producer
JFTP	Juvenile Fish Transportation Program
KAF	thousand acre-feet
kcfs	thousand cubic feet per second
kg/m^2	kilogram per meter squared
KW	kilowatt
KWh	kilowatt hour
LOA	Letter of Agreement
LWCFA	Land and Water Conservation Fund Act
M&I	municipal and industrial
MAF	million acre-feet
mg/l	milligram per liter
mm	millimeter
MOP	minimum operating pool
msl	mean sea level
MW	megawatt
MWh	megawatt hour
NAGPRA	Native American Graves Protection and Repatriation Act
NED	National Economic Development
NEPA	National Environmental Policy Act
Nez Perce	Nez Perce Tribe
NHPA	National Historic Preservation Act

Acronyms and Abbreviations (continued)

NMFS	National Marine Fisheries Service
N_2O	nitrous oxide
NO_2	nitrogen dioxide
NOx	nitrogen oxide
NPPC	Northwest Power Planning Council
NPS	National Park Service
NPTEC	Nez Perce Tribe Executive Council
NRHP	National Register of Historic Places
NTMP	neotropical migratory bird
NTU	nephelometric turbidity unit
O&M	operation and maintenance
O_3	ozone
OA	Columbia River Salmon Flow Measures Options Analysis
PATH	Plan for Analyzing and Testing Hypotheses
Pb	lead
PCB	polychlorinated biphenyl
PDO	Pacific Decadal Oscillation
PIT	passive induced transponder
PM	particulate matter
PM_{10}	particulate matter with aerodynamic diameters less than 10 micrometers
PMOA	Programmatic Memorandum of Agreement
PNCA	Pacific Northwest Coordination Agreement
PNI	Pacific Northwest Index
ppb	parts per billion
ppm	parts per million
PUD	Public Utility District
RCRA	Resource Conservation and Recovery Act
RED	Regional Economic Development
RM	River Mile
RPA	reasonable and prudent alternative
SAR	smolt-to-adult survival ratio
SBC	surface bypass collector
Scenic Area	Columia River Gorge National Scenic Area
SCS	System Configuration Study
SCT	System Configuration Team

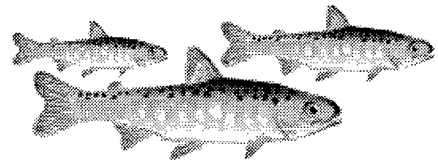
Acronyms and Abbreviations (continued)

SDWA	Safe Drinking Water Act
Shoshone-Bannock	Shoshone Bannock Tribes
SHPO	State Historic Preservation Office
SNL	speed no load
SO_2	sulfer dioxide
SOR	System Operation Review
SR	State Route
SRP	Science Review Panel
STS	submerged traveling screen
SWI	simulated Wells Dam intake
TAP	toxic air pollutant
TCR	transport:control ratio
TDG	total dissolved gas
TEQ	toxicity equivalency quotient
TIR	transport to in-river ratio
TMT	Technical Management Team
TPH	total petroleum hydrocarbons
TPY	tons per year
TSCA	Toxic Substance Control Act
TSS	total suspended solid
TVA	Tennessee Valley Authority
UI	University of Idaho
Union Pacific	Union Pacific Railroad
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compound
Warm Springs	Confederated Tribes of the Warm Springs of Oregon
WDFW	Washington Department of Fish and Wildlife
WRC	U.S. Water Resources Council
WRDA	Water Resources Development Act
WSCC	Western Systems Coordinating Council
Yakama	Yakama Nation



Chapter 1

Introduction



1. Introduction

Historically, runs of spring/summer chinook salmon (*Oncorhynchus tschawytscha*) were found throughout the accessible and suitable reaches of the Snake River and its tributaries. On the Snake River, they spawned as far upstream as Auger Falls in Idaho, some 930 miles from the mouth of the Columbia River. Fall chinook (*O. tschawytscha*) were also widely distributed in the mainstem of the Snake River (as far upstream as Shoshone Falls, Idaho) and the lower reaches of its tributaries. Snake River Sockeye salmon (*O. nerka*) were found in five lakes in the Stanley Basin, Big Payette Lake on the North Fork of the Payette River in Idaho, and Wallowa Lake in the Grande Ronde River Basin. Steelhead, the anadromous form of rainbow trout (*O. mykiss*), were also widely distributed in most accessible and suitable habitats.

Both the distribution and abundance of these anadromous fish species have declined significantly.

On November 20, 1991, the National Marine Fisheries Service (NMFS) declared the Snake River sockeye salmon endangered effective December 20, 1991 (56 Federal Register [FR] 58619). Snake River spring/summer chinook and Snake River fall chinook salmon were listed as threatened on April 22, 1992 (57 FR 14653). Critical habitat was designated for Snake River sockeye, spring/summer chinook, and fall chinook on December 28, 1993 (58 FR 68543). Snake River wild steelhead was formally listed as threatened on August 18, 1997 (62 FR 43937). Table 1-1 identifies the current status of listings for Columbia River salmon and trout species under the Endangered Species Act (ESA) of 1973, as amended.

Many anthropogenic (human-caused) factors are involved in the decline of the anadromous fish runs within the Snake River Basin. For example, between 1910 and 1967, several hundred miles of spawning area were lost because dams were built upstream from Hells Canyon Dam. Approximately 46 percent of the pre-dam anadromous fish habitat in the Snake River Basin was blocked by the construction of Brownlee Dam in 1958. This dam originally had fish passage facilities, but they were not successful in maintaining upstream runs. In addition, completion of Hells Canyon and Oxbow dams, downstream of Brownlee Dam, further blocked access to 247 miles of habitat in the Snake River (BOR, 1993).

Hells Canyon Dam is the current barrier to upstream migration of adult fish on the Snake River. Similarly, Dworshak Dam, completed in 1974, is a barrier to upstream migration on the North Fork Clearwater River.

Additional factors contributing to the decline of runs in the Snake River Basin include:

- Overharvest
- Loss of habitat
- Estuary destruction
- Influence of hatchery salmonids
- Problems associated with dams and reservoirs
- Other human-related problems (i.e., water quality, irrigation, urbanization, etc.).

Table 1-1. Federally Listed, Proposed, or Candidate Anadromous Fish Species (Ecologically Significant Units [ESUs]) in the Columbia River Basin

	Primary Region of Origin[1/]			
Species and ESU (Status, Fed. Reg. Month/Year)	Snake River	Upper Columbia River (above McNary Dam)	Middle Columbia River (Between McNary and Bonneville Dams)	Lower Columbia River (Below Bonneville Dam)
Snake River Fall Chinook Salmon (Threatened, 4/92)	X			
Snake River Spring/Summer Run Chinook Salmon (Threatened, 4/92)	X			
Snake River Sockeye Salmon (Endangered, 11/91)	X			
Snake River Steelhead (Threatened, 8/97)	X			
Upper Columbia River Spring Chinook Salmon (Endangered, 3/99)		X		
Upper Columbia River Steelhead (Endangered, 8/97)		X		
Middle Columbia River Steelhead (Threatened, 3/99)		X (Below Priest Rapids Dam)	X	
Southwest WA/Columbia River Coastal Cutthroat Trout (Proposed Threatened, 3/99)			X (Below The Dalles Dam)	X
Lower Columbia River/Southwest WA Coho Salmon (Candidate, 7/95)			X (Below The Dalles Dam)	X
Lower Columbia River Chinook Salmon (Threatened, 3/99)				X
Lower Columbia River Steelhead (Threatened, 3/98)				X
Columbia River Chum Salmon (Threatened, 3/99)				X
Upper Willamette River Chinook Salmon (Threatened, 3/99)				X
Upper Willamette River Steelhead (Threatened, 3/99)				X

[1/] Minor exceptions to distribution region may occur.

While the cumulative impact of overfishing and habitat degradation is considerable, NMFS has determined that the cumulative mortality of spring/summer chinook passing mainstem hydroelectric dams to be an important contributor to the decline of this species in the Columbia River. However, NMFS has determined that no single factor can be isolated as a primary cause of the decline in numbers of listed species (NMFS, 1995). Therefore, a multi-faceted ecosystem approach to species recovery with unified Federal coordination is desired to reverse the declines.

1.1 Feasibility Study Process

On March 2, 1995, NMFS issued its *Biological Opinion for the Reinitiation of Consultation on 1994-1998 Operation of the Federal Columbia River Power System and Juvenile Transportation Program in 1995 and Future Years.* The 1995 Biological Opinion established measures necessary for the survival and recovery of Snake River salmon stocks listed under the ESA.

The U.S. Army Corps of Engineers' (Corps') response to the 1995 Biological Opinion and, ultimately, this Feasibility Study evolved from a System Configuration Study (SCS) initiated in 1991. The SCS was undertaken to evaluate the technical, environmental, and economic effects of potential modifications to the configuration of Federal dams and reservoirs on the Snake and Columbia rivers to improve survival rates for anadromous salmonids. This process began in response to the Northwest Power Planning Council's (NPPC's) *Fish and Wildlife Program Amendments (Phase Two)* issued in December 1991 (NPPC, 1991).

The SCS was conducted in two phases. Phase I of the SCS was completed in June 1995. This was a reconnaissance-level assessment of multiple concepts, including drawdown, upstream collection, additional reservoir storage, migratory canal, and several other alternatives for improving conditions for anadromous salmonid migration. The results of the study were reported in the *Columbia River Salmon Migration Analysis, System Configuration Study, Phase I* (Corps, 1994). Alternatives that displayed the most potential benefit to anadromous fish were carried into Phase II (see Technical Appendix J, Plan Formulation.

Since 1995, Phase II has developed into a major program containing many separate and specific studies. Evaluation of structural changes for juvenile salmon migration improvements within the lower Snake River are only a portion of the total program. This growth in the scope of Phase II was considered necessary to adequately and efficiently respond to the requirements for multiple evaluations addressed in the 1995 Biological Opinion.

In December 1996, the Corps issued the *System Configuration Study, Phase II, Lower Snake River Juvenile Salmon Migration Feasibility Study, Interim Status Report* (Corps, 1996a) in response to the 1995 Biological Opinion requirement for a preliminary decision regarding the selection of drawdown alternatives. The alternatives evaluated in the *Interim Status Report* included:

- Existing conditions
- Three alternatives for lower Snake River drawdown, including:

1. Seasonal drawdown, near spillway crest
2. Seasonal drawdown, near natural river levels
3. Permanent drawdown, near natural river levels

- System improvements that could be accomplished without a drawdown, primarily through facilities that would improve downstream passage of juvenile fish.

None of these alternatives specifically incorporated a dam breaching scenario.

The findings published in the *Interim Status Report* indicated there was insufficient information at the time for the Corps to make a recommendation on the best configuration of the hydropower system to safely pass juvenile salmon in the lower Snake River. However, preliminary conclusions on the drawdown options indicated that seasonal spillway crest and seasonal natural river should be eliminated from further consideration. Consequently, the Corps recommended the continued investigation of three courses of action to improve salmon migration:

- Current fish programs
- Maximum collection and transport of juveniles with and without installation of surface bypass/collectors
- Dam breaching with permanent drawdown of all four lower Snake River reservoirs to natural river.

Evaluation of breaching only one, two, or three dams was not considered because removal of only one dam would eliminate major navigation and restrict options for collection and transportation of juvenile fish.

Because a decision on the best configuration of the hydrosystem for passage of juvenile salmon on the lower Snake River could not be made in 1996, a second decision point in 1999 was established, as identified in the 1995 Biological Opinion. This decision point has subsequently been shifted to 2000. The second decision point involving structural or operational changes to the lower Snake River dams resulted in this document (*Lower Snake River Juvenile Salmon Migration Feasibility Report and Environmental Impact Statement* [FR/EIS]). The FR/EIS is the document that the Corps will use to support its recommendation. Federal agencies involved in the development of this document besides the Corps are the cooperating agencies: Bonneville Power Administration (BPA), U.S. Environmental Protection Agency (EPA), U.S. Bureau of Reclamation (BOR), and other participating agencies including NMFS and U.S. Fish and Wildlife Service (USFWS).

1.2 Purpose and Need

A primary responsibility of the Corps in implementing long-term Biological Opinion alternatives is to conduct a study of those measures that are associated with dams and reservoirs and that influence migration through the hydrosystem. The purpose of the *Lower Snake River Juvenile Salmon Migration Feasibility Study* (Feasibility Study) is to evaluate and screen structural alternative measures that may increase the survival of juvenile anadromous fish through the Lower Snake River Project (which includes the four lowermost dams operated by the Corps on the Snake River—Ice Harbor,

Lower Monumental, Little Goose, and Lower Granite) and assist in the recovery of listed salmon and steelhead stocks.

The FR/EIS combines the format of a traditional Corps feasibility planning document and an EIS. The FR/EIS and associated technical appendices provide: 1) a complete presentation of study results and findings; 2) compliance with applicable statutes, Executive Orders, and policies; 3) a sound and documented basis with which both Federal and regional decision makers can judge the recommended solution; 4) scope, schedule, budgets, and technical performance requirements for the implementation of selected alternatives; and 5) documentation for Congressional authorization (if necessary) and/or subsequent funding for the implementation of any specific alternatives that need regional and Federal support. Therefore, in addition to describing the evaluation and screening of alternative measures that may increase the survival of juvenile anadromous fish through the Lower Snake River Project, this FR/EIS also meets the Corps' need to comply with the National Environmental Policy Act (NEPA).

1.3 Background

Numerous studies and decision documents have been prepared by the Corps and other Federal Columbia River Power System (FCRPS) operating and resource agencies that address salmon recovery and improved conditions for salmon survival. Important documents that provide specific background to this study on the lower Snake River include the *Final Columbia River System Operation Review EIS (*BPA et. al., 1995*);* the *Columbia River Salmon Flow Measures Options Analysis (OA)/EIS (*Corps, 1992*);* and the *Corps Interim Columbia and Snake River Flow Improvement Measures for Salmon Final Supplemental EIS* (Corps, 1993). Historically, the Corps has produced numerous documents that are relevant to the salmon restoration efforts in the FCRPS. These documents are incorporated by reference. Several of these documents and significant events are discussed in more detail in Technical Appendix R, Historical Perspectives. This FR/EIS tiers off previous studies and is being prepared directly in response to the requirements outlined in the 1995 Biological Opinion.

1.3.1 1995 Biological Opinion

In the 1995 Biological Opinion, NMFS determined that the planned and proposed actions for operation and juvenile transport programs were likely to jeopardize the continued existence of listed spring/summer chinook salmon. The 1995 Biological Opinion presented "reasonable and prudent alternatives" (RPAs) for operation of the FCRPS. In the 1995 Biological Opinion, NMFS concluded that implementation of the RPAs was not likely to jeopardize listed Snake River salmon. In the course of review and through the adaptive management process, NMFS further modified the RPAs on November 14, 1996. These modifications primarily addressed ongoing fish enhancement projects at Bonneville Dam and provided clarification for some typographical errors in the 1995 Biological Opinion (e.g., places where spring/summer chinook salmon were inadvertently substituted for "fall" chinook salmon in the incidental take statements).

The RPAs in the 1995 Biological Opinion provide the basis for the actions contemplated in this FR/EIS. As described above, the RPAs were designed to provide measures for the survival (and eventual recovery) of spring/summer chinook,

fall chinook, and sockeye salmon. The RPAs use an adaptive management approach for increasing survival and the probability of recovery of listed salmon by:

- Improved bypasses
- Increased spills and spring/summer flows
- Reduced fish handling
- Better fish transportation conditions.

Major structural modifications to dams have been identified in the RPAs and include installation of surface collectors and drawdowns (natural river or drawdowns to spillway crest). Planning and evaluations of potential modifications include:

- Evaluate in-river mitigation versus transport using Passive Integrated Transponder (PIT) tagged juveniles
- Evaluate in-river survivals using PIT tag data
- Install and test surface collection prototypes and evaluate their ability to improve in-river passage or collection efficiency
- Evaluate existing data to reduce uncertainty
- Complete planning tasks needed to begin drawdown.

These evaluations are expected to provide information on:

- Benefits of in-river versus transport survival
- Feasibility of surface collection technology's ability to improve in-river survival and/or collection efficiency
- Feasibility of natural river drawdown
- Feasibility of intermediate drawdown
- Levels of delayed mortality of transported smolts
- Improvements in either in-river or transport survival that provide a high probability for recovery without drawdowns.

Decision points:

- The Corps completed an interim status report on natural river drawdown, spillway crest drawdown, and surface collectors in 1996 (Corps, 1996a). This provided the basis for a preliminary decision on drawdown of the lower Snake River reservoirs.
- Engineering and design work on preferred drawdown alternative and surface collectors in 1996, unless the Corps and NMFS agree on a different course of action.
- Engineering and design work completed by December 1998.
- NEPA compliance in time to ensure a decision in 2000 (originally 1999) on drawdown or surface collectors.

1.3.2 1998 Biological Opinion

On August 18, 1997, NMFS announced the proposed listings of Snake River and Upper Columbia River Steelhead Evolutionarily Significant Units (ESUs) (62 FR 43937). These ESUs are defined as a distinct population segment of vertebrate fish or wildlife that is: 1) substantially reproductively isolated from other conspecific (same species) population units, and 2) represents an important component in the evolutionary legacy of the species (Waples, 1991).

The Federal operating agencies transmitted their *Biological Assessment for 1998 and Future Operation of the Federal Columbia River Power System (FCRPS), Upper Columbia and Lower Snake River Steelhead* to NMFS on January 21, 1998 (NMFS, 1998). This Biological Assessment (BA) included a request to consult further on lower Columbia River steelhead, which had only been proposed for listing at that time. On March 13, 1998, the lower Columbia River Steelhead ESU was listed as "threatened" by NMFS and was included in the consultation. Consultations ensued over the next two months and on May 14, 1998, NMFS issued its Supplemental Biological Opinion to the March 2, 1995 Biological Opinion (NMFS, 1998).

The 1998 Biological Opinion endorsed most parts of the 1995 Biological Opinion except that it modified plans for fish transportation and spill frequency. It also modified the spill criteria at Lower Granite in light of the success of new extended length screens and modified flow dates and specifications for spill operations at lower Snake River dams. The 1998 Biological Opinion laid out numerous specific terms and conditions for operations of the FCRPS to reduce juvenile and adult mortality.

The conclusions of the 1998 Biological Opinion were that the biological requirements of juvenile and adult Snake River steelhead and spring/summer chinook salmon are similar and that what helps one species will likely help the other. It was also determined that existing information is not sufficient to determine if the interim operations will meet the long-term biological needs of the listed species. The 1998 Biological Opinion considered the alternative actions being evaluated in this FR/EIS necessary in order to determine what actions are necessary to help with recovery of listed species. Importantly, the 1998 Biological Opinion found that lifecycle analyses for estimating probability of survival and recovery did not exist at that time.

In March 1999, NMFS listed six additional anadromous fish ESUs in the Columbia River Basin. These include three chinook salmon ESUs, one Columbia River chum salmon ESU, and two more listings of steelhead ESUs. As a result, the recovery actions on the lower Snake River will require further coordination to ensure actions on the lower Snake River do not adversely affect recovery plans for other Columbia River Basin listed fish and wildlife.

A BA that addresses the effects of the preferred alternative on others listed in the Columbia River Basin is being prepared as part of the continuing consultation with NMFS and USFWS for this FR/EIS. The BA will be submitted to these agencies for review. The agencies will respond by preparing a Biological Opinion that will state whether or not the preferred alternative is likely to jeopardize the continued existence of listed species.

1.4 Scope

This FR/EIS provides river managers, users, and the general public an opportunity to examine alternative river system operational and structural measures in detail. It also assists those groups in determining how each use of the river affects other uses, and to consider the consequences of changing the way the Lower Snake River Project currently operates. This first section of this FR/EIS lays the groundwork for later sections and describes the background on how the FR/EIS has arrived at this point in the review process. This section also describes major entities and programs that are involved in the management of the Columbia River System, with particular emphasis on those that deal with the management of the system and the effects it may have on listed species. Subsequent sections describe the existing Lower Snake River Project, detail the alternatives developed through this EIS process, discuss the effects of changing how the system functions, and explain the tradeoffs among uses that the various alternatives would precipitate. These sections include:

- **Section 2–Affected Projects and Programs.** This section describes key features of the Lower Snake River Project, with specific details on each facility (i.e., Ice Harbor, Lower Monumental, Little Goose, and Lower Granite).
- **Section 3–Plan Formulation.** This section identifies the four alternatives that were evaluated. It also describes other potential actions that may affect the survival of juveniles, but were outside the scope of this FR/EIS. Finally, it addresses alternatives that were considered but eliminated from further consideration for various reasons.
- **Section 4–Affected Environment.** This section describes current conditions for a number of resource areas (e.g., fish, wildlife, water quality, historic resources, recreation, economics, and others).
- **Section 5–Environmental Effects of Alternatives.** This section evaluates the potential effects of each alternative (1 through 4) on the affected environment and in fulfilling the need for action.
- **Section 6–Plan Selection.** This Draft FR/EIS evaluates the effects of the four alternatives in detail. However, the results of the evaluation do not clearly define an alternative that would be superior and thus "preferred" over the others. Therefore, this Draft FR/EIS provides information and analyses that can be used to compare the alternatives. Through the review process, additional views, opinions, and information are anticipated. These will be evaluated and considered in the selection of the preferred alternative, which will be described in the Final FR/EIS.
- **Section 7–Plan Implementation.** This section describes the steps and regulatory processes for implementing the preferred alternative.
- **Section 8–Public Involvement.** This section describes the public involvement activities (e.g., scoping meetings, informational meetings, newsletters, internet sites) that have taken place to date for this FR/EIS. It also describes the future schedule for review of this Draft FR/EIS, additional opportunities (such as public meetings) for public involvement, and other means for the public to provide input to the process that leads to a final determination.

- Sections 1 through 8 introduce and address the environmental consequences of the alternatives. The following sections (Sections 9 through 13) provide information on compliance with other regulations, information required by the NEPA process, or useful supporting documentation:
  - Section 9–Compliance with Applicable Federal Environmental Statutes and Regulations
  - Section 10–Literature Cited
  - Section 11–Glossary
  - Section 12–List of Preparers
  - Section 13–Distribution List.

The main text of this FR/EIS is further supported by more detailed technical appendices (Technical Appendices A through U) that address specific topics (e.g., anadromous fish, economics, engineering).

Because the alternatives considered in this study would affect resources of concern to all people of the Pacific Northwest, the Corps structured the Feasibility Study to involve participation of the whole region. The ultimate decision and process for decision making in this study is regional in scope and therefore several Federal agencies, states, and tribes are direct participants in the FR/EIS process. The BOR, BPA, and EPA are all cooperating agencies of this study. The Corps is also working with American Indian representatives, elected officials, other Federal and state agencies, and special interest groups throughout the region. The Corps has gathered and continues to gather input from interested parties to define and evaluate the primary alternatives identified for improving juvenile salmon and steelhead survival rates.

1.4.1 Scoping and Public Involvement

The Feasibility Study was officially announced to the public on June 5, 1995. On that date, the Corps' notice of intent to prepare a Draft FR/EIS appeared in the *Federal Register* (Monday, June 5, 1995 [29578] Vol. 60, No. 107).

In July 1995, the Corps conducted four public scoping meetings to initiate the Feasibility Study and begin the NEPA process. Each public meeting consisted of an open house and formal meeting. Since the scoping meetings, the Corps has conducted numerous other regional meetings, known as Regional Roundtable Workshops, as well as public outreach meetings to allow the public an opportunity to participate further in the study. Four public information meetings were held throughout the region in September 1997 and another five were conducted in November 1998 (see Technical Appendix O, Public Outreach Program, for additional details).

1.4.2 Screening Analysis

The technical analyses and screening of potential options in the Feasibility Study have been conducted in a variety of ways, including the use of workgroups. For example, there are workgroups for carrying out complex biological and economic evaluations. The Drawdown Regional Economic Workgroup (DREW) was a group of regional economists studying the economic issues associated with alternative

actions on the lower Snake River. The Plan for Analyzing and Testing Hypotheses (PATH) workgroup is a group of state, tribal, Federal, and independent scientists from within and outside the region that projected salmon and steelhead survival rates under various alternatives. In addition to the workgroups, there are also engineers and planners designing and screening specific structural changes that could help more salmon and steelhead pass safely through the dams. The results of these efforts are incorporated into this FR/EIS.

1.4.3 Geographic Scope

The geographic and jurisdictional scope for the proposed action are based on the purpose and needs identified in Section 1.2, Purpose and Need. The proposed actions contemplated would be implemented as appropriate at each of four dams along the lower Snake River.

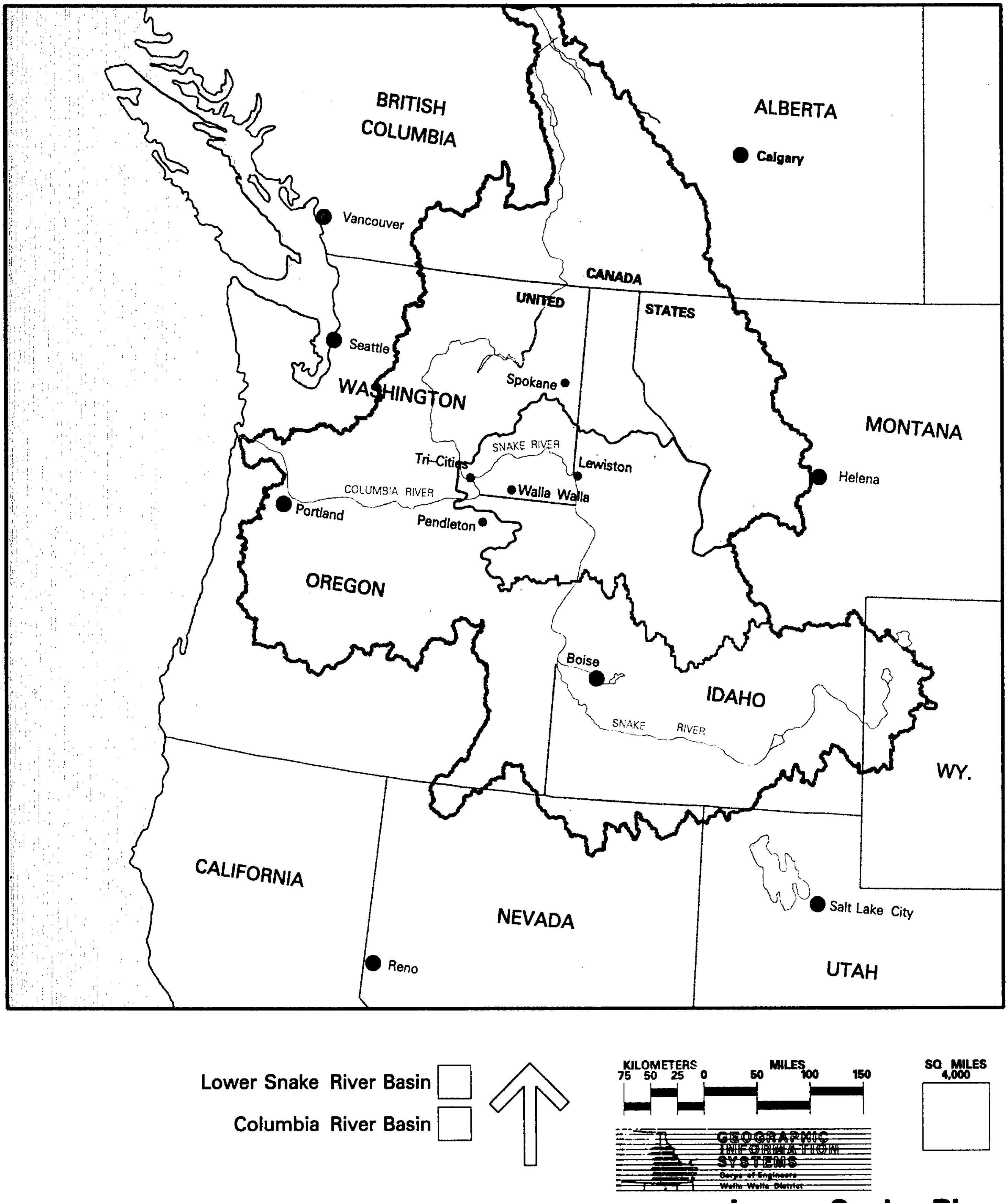
The FR/EIS coverage of the affected environment and environmental consequences focuses on the 140-mile-long lower Snake River reach between Lewiston, Idaho, and the Tri-Cities in Washington (Figures 1-1 and 1-2). The study area does slightly vary by resource area in the FR/EIS because the affected resources have widely varying spatial characteristics throughout the Lower Snake River Project. From a socioeconomic perspective, the effects of a permanent drawdown could be felt throughout the whole Columbia River Basin region, with the most pronounced effects taking place in the counties of southeast Washington.

1.4.4 Regional Forum

This FR/EIS examines a number of alternatives that address just hydropower actions on the four lower Snake River dams. In order to meet the much broader needs of ESA-listed salmon of the entire Columbia River Basin, the 1995 Biological Opinion established an inter-Governmental forum involving Federal, state, tribal, and other representatives for decisionmaking. This forum, named the Regional Forum, is multi-leveled (see Figure 1-3).

The overall objective of the Regional Forum is for the technical teams to explore relevant facts and analyze, as necessary, in order to define the issues regarding ESA-listed salmon and steelhead in the Columbia River Basin. If an issue cannot be resolved at the technical levels, the issue is raised to the manager level for resolution. The main intent of the Regional Forum is to allow the Executive Committee, the Implementation Team, and the various technical teams to have opportunities for discussions of both scientific and management issues.

The Regional Forum includes the Technical Management Team which makes decisions about the in-season operation of the FCRPS to benefit salmon. In addition, it includes a parallel System Configuration Team (SCT) that was established to consider modifications to the physical structures of dams in the hydro system. PATH is a structured program of formulating and testing hypotheses involving the fundamental biological issues surrounding recovery of ESA-listed salmon and steelhead species in the Columbia River Basin. The PATH decision analysis, under the direction of the Implementation Team, has been focused on alternative hydrosystem actions that may be used to prevent the extinction and aid in the recovery of listed stocks.



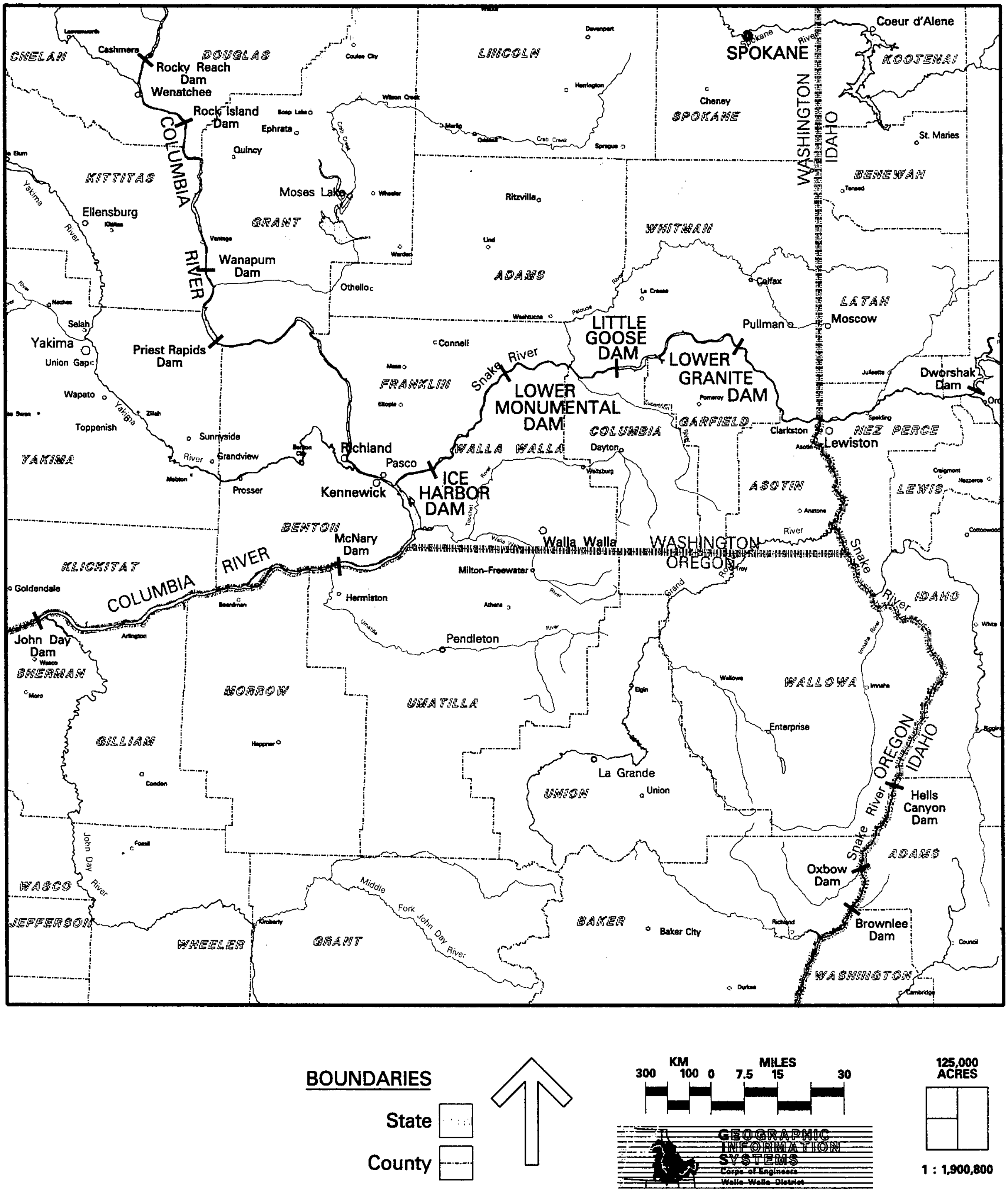
DRAFT

Lower Snake River
Juvenile Salmon Migration Feasibility Study

Figure 1–1. PROJECT VICINITY

g:\regional\crbasin\plates\crbpv.dgn:GISFILE PLOTTED: 06 DEC 1999

1999



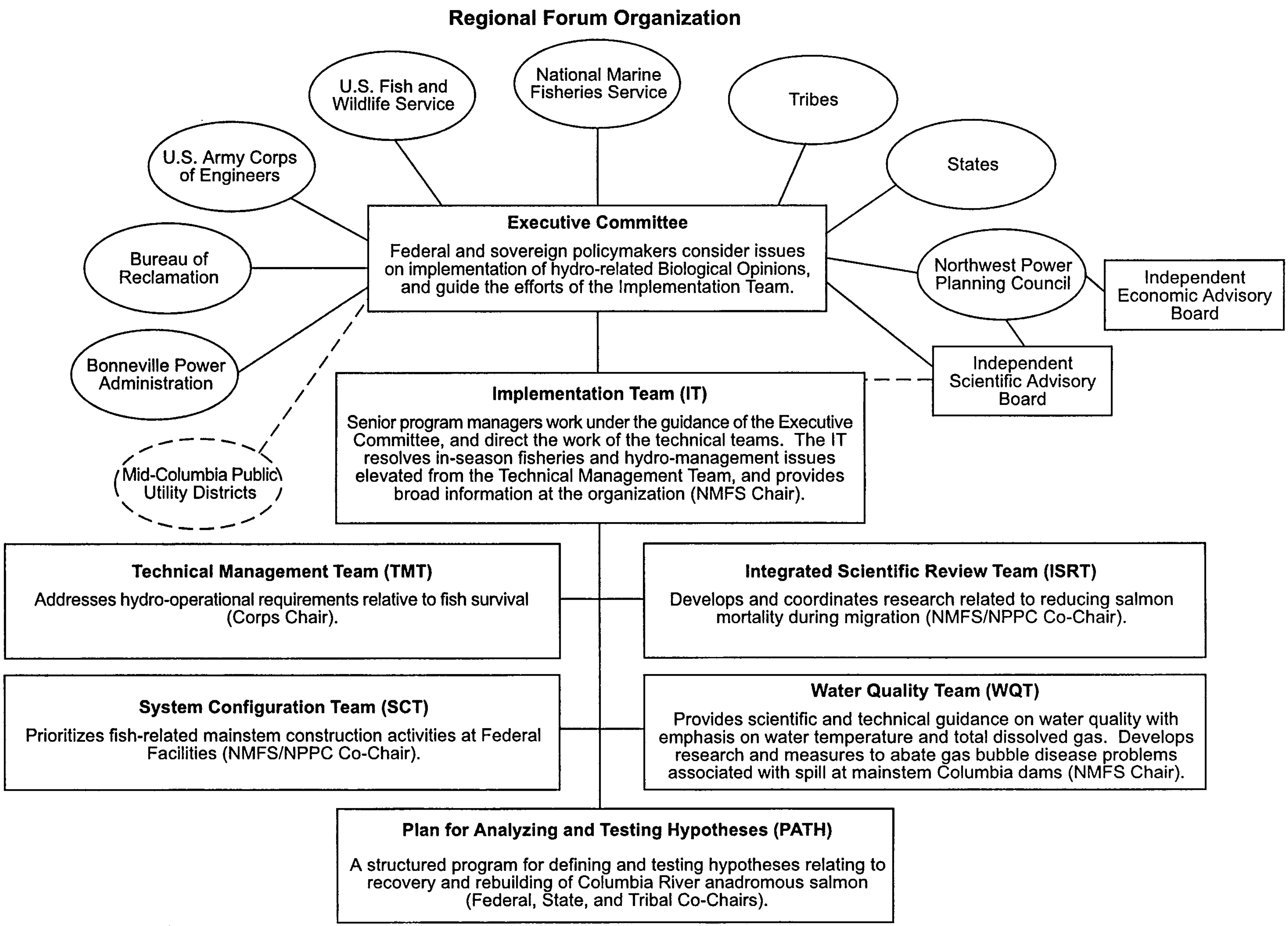
DRAFT

Lower Snake River
Juvenile Salmon Migration Feasibility Study

Figure 1–2.
REGIONAL BASE MAP

1999

GIS Analysts & Graphic Assembly: Applied Technology Team (CENWW-PM-PD-E)
g:\regional\reg\plates\lsr\jsmeis\lsrg\lsrgbm.dgn:GISFILE PLOTTED: 06 DEC 1999



Source: http/www.nww.usace.army.mil/html/offices/pl/er/studios/lsrpublic/orgcht.htm 10/99

Figure 1-3. Regional Forum Organization

The Water Quality Team provides scientific and technical recommendations and advice on water quality issues. The team's current emphasis is on water temperature and total dissolved gas in the Columbia River Basin.

The Integrated Scientific Review Team develops and coordinates research throughout the Columbia River Basin on approaches for reducing salmon and steelhead mortality during migration.

The Implementation Team assists with resolution of the issues generated by these two technical teams, as well as others. The Executive Committee deals with issues at the policy level.

The results of this FR/EIS are major components of the overall Regional Forum's decisionmaking process. However, the Regional Forum is not only focused on the lower Snake River. In addition, work or studies on other projects in the basin (e.g., Bonneville, The Dalles, John Day, and McNary) are included in the Regional Forum's scope of activities in planning recovery efforts for ESA-listed fish.

1.4.5 Additional Fish and Wildlife Planning Groups and Activities in the Columbia River Basin

A number of resource agencies, tribes, organizations, stakeholders, and the public have direct interest or responsibilities in developing management plans that affect recovery efforts of ESA-listed fish species in the Columbia River Basin and the operation of the FCRPS. The following identifies some of the main organizations and their roles in planning efforts for listed anadromous fish in the Basin. Technical Appendix R, Historical Perspectives, provides a more detailed description of the historical perspective of events or processes since 1990 that have lead to the development of this FR/EIS.

1.4.5.1 U.S. Army Corps of Engineers/Bureau of Reclamation

The Corps and BOR are responsible for the operation and maintenance of Federal dams in the FCRPS. For example, major facilities under the Corps' management include the four lower Columbia mainstem dams (i.e., McNary, John Day, The Dalles, and Bonneville), the four dams on the lower Snake River (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor), and Chief Joseph and Dworshak dams. The BOR is responsible for other mainstem Federal projects such as Grand Coulee Dam. Corps and BOR facilities affect biological, economic, social, and other resources in the Columbia River Basin. Both agencies are involved in the evaluations and implementation of measures that address ESA-listed fish species affected by their respective facilities.

1.4.5.2 U.S. Federal Energy Regulatory Commission

Major non-Federal dams are owned, operated, and maintained by various entities including Public Utility Districts (PUDs) (e.g., Chelan, Douglas, and Grant counties) and private utilities (e.g., Idaho Power Company). These non-Federal dams are regulated by the licensing process of the U.S. Federal Energy Regulatory Commission (FERC). Similar to the Corps and BOR facilities, the public and private utility projects also affect the resources of the Columbia River Basin. Through a licensing

process, measures are evaluated and implemented that address ESA-listed fish species affected by FERC-licensed facilities.

1.4.5.3 Bonneville Power Administration

BPA markets and distributes power generated from Federal dams in the Columbia River Basin and other generating plants. The agency sells the power to public and private utilities and large industries, and it builds and operates transmission lines that deliver electricity. BPA funds a wide range of fish and wildlife programs throughout the Columbia River Basin. Funding for these programs is derived from revenues produced through sales of power generated from Federal dams in the Columbia River Basin.

1.4.5.4 U.S. National Marine Fisheries Service

In the Pacific Northwest, NMFS' responsibilities are to conserve, protect, and manage Pacific salmon, groundfish, halibut, and marine mammals and their habitats under the ESA and other laws. Species in the Columbia River include salmon, steelhead, and other anadromous fish. NMFS will prepare a Biological Opinion (anadromous fish aspects) in response to the recommendation made in this FR/EIS.

1.4.5.5 U.S. Fish and Wildlife Service

The responsibilities of the USFWS are similar to NMFS, but apply to resident fish, wildlife, and plant species and their habitat. USFWS has the main role of preparing the resident fish, wildlife, and plant species aspects of the Biological Opinion in response to the decision that will be made in 2000. In addition, the USFWS has prepared the Fish and Wildlife Coordination Act Report (FWCAR) for the Corps' FR/EIS (see Technical Appendix M, Fish and Wildlife Coordination Act Report).

1.4.5.6 U.S. Environmental Protection Agency

The EPA is responsible for managing and enforcing water quality regulations in the nation's waters. It also regulates discharge of pollutants into water and air. Under the Clean Water Act, EPA, the states, tribal governments, other Federal agencies, and private landowners will implement numerous programs throughout the Columbia River Basin that are aimed at watershed and tributary improvements to meet requirements of the Clean Water Act. These programs will be implemented in the mainstem and tributaries and will focus on improving water quality, restoration of habitat, and recovery of ESA-listed species. The EPA also conducts various studies throughout the Columbia River Basin. For example, it is currently conducting a water temperature modeling study on the lower Snake River, including the Lower Snake River Project and upstream tributaries.

1.4.5.7 Federal Caucus

The Federal Caucus includes NMFS, Corps, BOR, BPA, EPA, Bureau of Indian Affairs (BIA), Bureau of Land Management (BLM), USFWS, and United States Department of Agriculture (USDA) Forest Service. The primary role of the Federal Caucus is to develop a multi-species recovery plan that defines Federal obligations consistent with the ESA as well as non-Federal activities (e.g., state, local, and private) necessary for recovery of ESA-listed species in the Columbia River Basin.

The multi-species recovery plan is focused on the so-called four H's (hydro, habitat, harvest, and hatcheries), which are broad categories of the human activities that may affect listed species in the Columbia River system. The Federal agencies are currently preparing a "Four H Paper" that explains how management of the hydropower system fits into the overall recovery strategy.

1.4.5.8 Columbia River Basin Forum

The Columbia River Basin Forum (formerly known as the Three Sovereigns) was formed to allow regional governments, interested parties, and the general public the opportunity to discuss management approaches for Columbia River Basin resources and to determine if regional agreement can be made on possible alternatives. The goal of the Columbia River Basin Forum is to develop regionally agreed upon recommendations for fish and wildlife recovery. A goal of the Columbia River Basin Forum is to improve the coordination of the many decision processes in the Columbia River Basin such as the feasibility decision that will be made in 2000.

1.4.5.9 Tribal Caucus

Thirteen Indian tribes have management authority for fish, wildlife, and water resources within their reservations, as well as other legal rights included in Treaties and Executive Orders. These tribes are members of the Tribal Caucus. The primary role of the Tribal Caucus is to identify consensus views among the participating tribes. The 13 tribes are the Confederated Tribes of the Colville Reservation, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation, the Confederated Tribes and Bands of the Yakama Nation, the Nez Perce Tribe, the Spokane Tribe of Indians, the Coeur d'Alene Tribe, the Kalispel Tribe of Indians, the Kootenai Tribe of Idaho, the Salish-Kootenai Tribes of the Flathead Indian Reservation, the Shoshone-Bannock Tribes of the Fort Hall Reservation, the Burns-Paiute Tribe, and the Shoshone-Paiute Tribes of the Duck Valley Reservation.

1.4.5.10 Columbia River Inter-Tribal Fish Commission

The Columbia River Inter-Tribal Fish Commission (CRITFC) is the technical support and coordinating agency for fishery management policies of the four Columbia River treaty tribes. These tribes include: Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe. Membership is composed of the fish and wildlife committees of these tribes. CRITFC responsibilities include fisheries research and analyses, advocacy, planning and coordination, harvest control, and law enforcement.

1.4.5.11 Wy-Kan-Ush-Mi Wa-Kish-Wit

Wy-Kan-Ush-Mi Wa-Kish-Wit is the Columbia River Anadromous Fish Plan of the Nez Perce, Umatilla, Warm Springs, and Yakama tribes. The plan provides a framework for restoration of Columbia River salmon.

1.4.5.12 State Agencies

Washington, Oregon, Idaho, and Montana represent distinct management entities with authority over fish, wildlife, and water resources within their jurisdictions. The agencies in these states have developed a number of management and recovery plans for fish and wildlife in the Columbia River Basin.

1.4.5.13 Columbia Basin Fish and Wildlife Authority

The Columbia Basin Fish and Wildlife Authority (CBFWA) was established to coordinate the efforts of its members (state, tribal, and Federal fish managers) to protect and enhance fish and wildlife resources by:

1. Coordinating the fish and wildlife activities of concern to the members
2. Facilitating the members' involvement in the implementation of the NPPC's Fish and Wildlife Program
3. Interfacing with water and land planning and management authorities of the Columbia River Basin.

1.4.5.14 Northwest Power Planning Council

The NPPC is a regional agency of the states of Idaho, Montana, Oregon, and Washington that was created under the authority of the Pacific Northwest Electric Power Planning and Conservation Act of 1980. The NPPC's primary role is to conduct long-range energy and fish and wildlife planning in the region. The NPPC has three distinct tasks:

1. Prepare a regional conservation and electric power plan to meet future energy needs, giving first priority to cost-effective energy conservation and second priority to cost-effective renewable resources.
2. Prepare a program to protect, mitigate, and enhance fish and wildlife, including spawning grounds and habitat, on the Columbia River and its tributaries.
3. Ensure widespread public involvement in the formulation of the power plan and the NPPC's Fish and Wildlife Program.

The NPPC makes recommendations to BPA on the utilization of ratepayer funds for the Fish and Wildlife Program. The Fish and Wildlife Program is revised periodically and will respond to the feasibility decision in 2000.

1.4.5.15 Multi-Species Framework

In response to two scientific reviews on the NPPC's Fish and Wildlife Program, a science-based framework was initiated to help guide management policy. The framework is used to develop options for future management of the Columbia River Basin, including the biological, social, and economic effects of the options. The framework process has identified seven options that range from those that are highly protective of the ecology to those that are highly protective of the economic resources. States, tribes, Federal agencies, NPPC staff, and stakeholders are participating in the development and analysis of the alternatives.

1.5 Alternatives

This FR/EIS analyzes a range of possible actions on the lower Snake River. Other aspects of the Columbia River and upper Snake River operations are addressed under other related study processes. For example, there are several related processes underway that address structural and operational changes in other parts of the Columbia River System (see Section 3.5, Other Potential Actions Outside the Scope of the FR/EIS, for additional discussion of these related processes). Many alternatives have been considered and are being considered in this study process. As described above, there are numerous study groups and collaborative efforts underway that are assisting in the evaluation of alternatives.

Since the beginning of the Feasibility Study, alternatives have been identified and given numbering or lettering schemes to serve as unique identifiers. However, different study groups have used slightly different numbering or lettering schemes. Rather than try to carry forward the complex, and often conflicting, numbering and lettering schemes, this FR/EIS uses short names to label the alternatives that are considered in detail (Table 1-2). The alternatives that are considered in detail include:

- **Alternative 1—Existing Conditions** (commonly called Alternative A1 in supporting study reports and A-1 by PATH)—the existing hydrosystem operations under the 1995 and 1998 Biological Opinions.
- **Alternative 2—Maximum Transport of Juvenile Salmon** (called Alternative A2a in supporting study reports and A-2 by PATH)—the existing hydrosystem operations and maximum transport of juvenile salmon, but without surface collectors.
- **Alternative 3—Major System Improvements** (called Alternative A2b [a low cost option] in supporting study reports and A-2′ by PATH)—the existing hydrosystem operations and maximum transport of juvenile salmon, but with major system improvements that could be accomplished without a drawdown.
- **Alternative 4—Dam Breaching** (called Alternative A3 in supporting study reports and A-3 by PATH)—drawdown of the four lower Snake River reservoirs (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor) to natural river conditions.

Table 1-2. Alternative Designations for this FR/EIS and Previous Designations in Other Reports

FR/EIS Alternative	Supporting Studies/Other Alternative Designations	PATH Alternative
Alternative 1—Existing Conditions	A1	A-1
Alternative 2—Maximum Transport of Juvenile Salmon	A2a	A-2
Alternative 3—Major System Improvements	A2b	A-2′
Alternative 4—Dam Breaching	A3	A-3

1.6 Authority

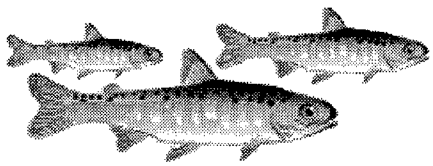
The Lower Snake River Project (which is the name for the Corps' four lower Snake River facilities combined) was constructed and is operated and maintained under laws that may be grouped into three categories: 1) laws initially authorizing construction of the project (i.e., Public Law 79-14); 2) laws specific to the project passed subsequent to construction; and 3) laws that generally apply to all Corps projects. Using these and other authorities, the Corps operates multiple-use water resource development projects to balance operation of individual functions with operations for all functions. This operation is coordinated with BPA, BOR, and other regional interests. The authorized uses of the Lower Snake River Project are power generation and inland navigation, fish and wildlife, irrigation, and recreation. These uses have been authorized under several public laws (Table 1-3).

Table 1-3. Authorized Purposes of Lower Snake River Project Facilities

Authorized Purposes	Authorizing Laws
Navigation	Public Law 79-14
Irrigation	Public Law 79-14
Recreation	Public Law 78-534
Hydroelectric Power	Public Law 79-14
Fish/Wildlife	Public Law 85-624

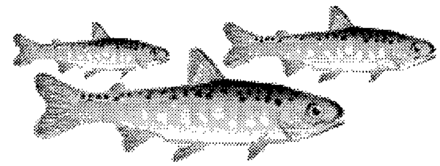
Source: Corps, 1992

The Feasibility Study was conducted with consideration of authorization legislation and other laws including ESA; the Pacific Northwest Electric Power Planning and Conservation Act; the Fish and Wildlife Coordination Act; Section 216 of the 1970 Flood Control Act; River and Harbor Act of 1945; Sections 103, 105, and 905 of the 1986 Water Resources Development Act; Water Supply Act; Federal Water Pollution Control Act; and the water resources appropriations bills passed by Congress in 1996, 1997, and 1998. In particular, the ESA requires all Federal agencies to ensure that actions taken by the agency are not likely to jeopardize the continued existence of a species that has been listed as threatened or endangered or result in the destruction or adverse modification of critical habitat. In addition, the ESA provides agencies with the responsibility to carry out programs for the conservation of listed species.



Chapter 2

Affected Projects and Programs



2. Affected Projects and Programs

The Columbia River is the fourth largest river in North America. It originates at Columbia Lake in the Columbia Mountains of British Columbia, Canada and flows 1,214 miles to the Pacific Ocean (Figure 1-1). From its source, the river flows northwest for approximately 200 miles, then reverses course and travels south for nearly 300 miles through mountainous terrain in southeastern British Columbia. The Columbia River crosses into the United States near the northeastern corner of Washington State and continues south through highlands before bending westward. After looping again to the east, the river turns westward and flows for over 300 miles between Washington and Oregon to the sea.

The Columbia River Basin drains over 259,000 square miles. It produces an average annual runoff at The Dalles of about 173 million acre-feet (MAF) (enough water to cover 173 million acres to a depth of 1 foot). The drainage area comprises most of Washington, Oregon, and Idaho; the western quarter of Montana; the southeastern corner of British Columbia; and small portions of Wyoming, Utah, and Nevada. There are more

than 150 dams and reservoirs whose operations are coordinated in the basin—31 of them are operated by Federal agencies.

The Snake River is a major tributary to the Columbia River. The Snake River drains an area of about 109,000 square miles, including portions of Idaho, northwestern Wyoming, northern Utah and Nevada, southeastern Washington, and eastern Oregon) (Figure 1-1). Major tributaries downstream of Hells Canyon Dam include the Salmon, Grand Ronde, Imnaha, Clearwater, Tucannon, and Palouse rivers. The Snake River flows through a canyon of varying depths from about 5,500 feet in upstream Hells Canyon to less than 450 feet near its confluence with the Columbia River. Much of the lower Snake River Canyon is generally steep, with basalt bluffs rising up to 2,000 feet to rolling uplands.

Most juvenile salmon originating from the Snake River Basin make their way past eight Federal dams and reservoirs on the lower mainstem Snake and Columbia rivers before reaching the Pacific Ocean (Figure 1-1).

This FR/EIS is concerned with actions for improving fish passage at the four Federal dams on the lower Snake River. This section summarizes key project and program information for these four dams, which make up the Lower Snake River Project. It includes a description of the facilities at each dam and a discussion of existing river system fish programs. These four dams are all equipped with passage systems for adult and juvenile fish. The systems are continually being improved as new technologies for passage are developed.

2.1 Project Characteristics

The four lower Snake River dams—Lower Granite, Little Goose, Lower Monumental, and Ice Harbor—are multiple-use facilities that provide public benefits in many different ways. The Lower Snake River Project uses are inland navigation, hydropower generation, irrigation, recreation, and fish and wildlife. Project facilities include dams and reservoirs, hydroelectric powerplants and high-voltage transmission lines, navigation channels and locks, juvenile and adult fish passage structures, fish hatcheries, parks and recreational facilities, lands dedicated to project operations, and areas set aside as wildlife habitat.

All four lower Snake River dams are run-of-river facilities. They are not authorized, designed, or operated for flood control. These run-of-river facilities have limited storage capacity and pass water at nearly the same rate as the water enters each reservoir. Reservoir levels behind these dams vary only a few feet during normal operations. This limited storage is used for hourly regulation of powerhouse discharges to follow daily and weekly demand patterns. This storage is not enough to allow seasonal regulation of streamflows. Other Federal dams on the Columbia River and its tributaries were developed for storage purposes. Storage reservoirs, such as the Dworshak Reservoir on the North Fork of Clearwater River, are used to store water and adjust the river's natural flow patterns to conform more closely with water uses.

The normal operating ranges and usable storage volumes for the affected four lower Snake River facilities are listed in Table 2-1. While it is physically possible to draw run-of-river reservoirs well below their normal minimum pool levels, the four lower Snake River facilities are not designed to operate below minimum pool levels.

Table 2-1. Characteristics of the Four Lower Snake River Facilities

Facility	Type of Facility	Snake River Mile	Reservoir Name	Reservoir Capacity 1/ (acre-feet)	Total Reservoir Capacity (acre-feet)	Reservoir Elevation 1/ (msl)
Lower Granite	Run-of-River	107.5	Lower Granite Lake	49,000	483,800	733 to 738
Little Goose	Run-of-River	70.3	Lake Bryan	49,000	565,200	633 to 638
Lower Monumental	Run-of-River	41.6	Lake Herbert G. West	20,000	432,000	537 to 540
Ice Harbor	Run-of-River	9.7	Lake Sacajawea	25,000	406,500	437 to 440

1/ normal operating range
msl = mean sea level
Source: Corps and NMFS, 1994

The following sections describe the features that are generally present at all four lower Snake River facilities.

2.1.1 Adult Fish

The Lower Snake River Project was originally designed and constructed with adult passage facilities at the four dams. These facilities include fish ladders, pumped attraction water supplies, and powerhouse fish collection systems (Table 2-2). The adult fish passage facilities at each dam have certain features in common (Figure 2-1). In general, there is a set of main fishway entrances near the far end of the spillway, between the spillway and powerhouse, and at the near end of the powerhouse. Two entrances are typically used at each location. Additional smaller entrances (floating orifice gates) are provided across the face of the powerhouse.

Figure 2-1. Existing Adult Fish Passage Systems

Table 2-2. Components of Juvenile and Adult Fish Passage Facilities at the Lower Snake River Project

	Juvenile Fish Passage Facilities	Adult Fish Passage Facilities
Lower Granite Dam	**Bypass System** • extended submerged bar screens (ESBSs) with flow vanes • improved modified balanced flow vertical barrier screens • gatewell orifices (10 inch) • bypass channel running the length of the powerhouse • bypass pipe to transportation facilities or river **Transportation Facilities** • upwell and juvenile/adult separator structure • raceways for holding fish • distribution system (to raceways, barge, or river) • sampling and marking building • truck and barge loading facilities • Passive Induced Transponder (PIT) tag detection and deflection systems	**North Shore Fish Collection** • two downstream entrances • one side entrance into stilling basin on north end of spillway • tunnels connect these fishway entrances to powerhouse's collection system **South Shore Fish Ladder** • two south shore entrances **Powerhouse Collection System** • two downstream entrances • one side entrance into spillway basin • common transportation channel • ten floating orifices **Auxiliary Water Supply System**
Little Goose Dam	**Bypass System** • ESBSs with flow vanes • vertical barrier screens • gatewell orifices (12 inch) • bypass channel running the length of the powerhouse • metal flume on face of dam and upper end of fish ladder • dewatering structure • two emergency bypass systems • corrugated metal flume (to transportation facilities or river) **Transportation Facilities** • upwell and juvenile/adult separator structure • raceways for holding fish • distribution system (to raceways, barge, or river) • sampling and marking building • truck and barge loading facilities • PIT tag detection and deflection systems	**North Shore Fish Collection** • two downstream entrances • one side entrance into stilling basin on north end of spillway • tunnels connect these fishway entrances to powerhouses collection system **South Shore Fish Ladder** • two south shore entrances **Powerhouse Collection System** • two downstream entrances • one side entrance into spillway basin • common transportation channel • four floating orifices **Auxiliary Water Supply System**

Q:\1346\DEIS\12727t.DOC

Table 2-2. Components of Juvenile and Adult Fish Passage Facilities at the Lower Snake River Project

	Juvenile Fish Passage Facilities	Adult Fish Passage Facilities
Lower Monumental Dam	**Bypass System** • standard length submerged traveling screens (STSs) • vertical barrier screens • gatewell orifices (12 inch) • collection channel • dewatering structure • bypass flume (to tailrace below the dam) **Transportation Facilities** • upwell and juvenile/adult size separator structure • sampling facilities • raceways for holding fish • office and sampling building • truck and barge loading facilities • PIT tag detection and deflector systems	**North Shore Fish Ladder** • two north shore entrances • connects to powerhouse collection system **South Shore Fish Ladder** • two downstream entrances • one side entrance into spillway basin **Powerhouse Collection System** • two downstream entrances • one side entrance into spillway basin • common transportation channel • ten floating orifices **Auxiliary Water Supply System**
Ice Harbor Dam	**Bypass System** • standard length STSs • vertical barrier screens • gatewell orifices (12 inch) • collection channel • dewatering structure • sampling and marking building **Transportation Facilities** • transportation flume/pipe to tailrace (below dam)	**North Shore Fish Ladder** • counting station **North Shore Collection System** • two downstream entrances • one side entrance into spillway basin • counting station **North Shore Auxiliary Water Supply System** **South Shore Fish Ladder** • counting station • two south shore entrances **South Shore Powerhouse Collection System** • two downstream entrances • one side entrance into spillway basin • common transportation channel • twelve floating orifices **South Shore Auxiliary Water Supply System**

Source: Corps, 1999a.

C:\WALLA WALLA - SHARED\1346\DEIS\12727t.DOC

Adult fish passage facilities are operated in accordance with the Corps' Fish Passage Plan (Corps, 1999a) as prescribed in the 1995 and 1998 Biological Opinions. Fish ladders typically operate all year with two weeks shutdown for maintenance in the January through March timeframe. Fish counting is done April through October at Ice Harbor, Lower Monumental, and Little Goose, and April through December at Lower Granite.

Studies are underway to improve facilities and operations in accordance with the 1995 and 1998 Biological Opinions. For example, modifications to the adult fish attraction water system are being considered for all adult fishways at each lower Snake River dam, in accordance with the 1995 Biological Opinion. Possible modifications could include electrical upgrades to provide more reliable sources of electrical power to the attraction water pumps (used to create currents that attract adult fish to fish ladders), upgrading existing pumps, or adding new pumps or a gravity-fed system for the attraction flow. These measures would ensure an adequate water supply for the fish ladders in the event of a pump failure. Additional ongoing studies are focused on adult fish fallback, a situation where adult fish pass upstream through the fish ladder, but pass back downstream via the spillway, powerhouse, or navigation lock.

2.1.2 Juvenile Fish

Juvenile fish bypass facilities were installed at each of the four lower Snake River dams shortly after they were constructed (Figures 2-2a and 2-2b and Table 2-2). The facilities were upgraded as new technology developed.

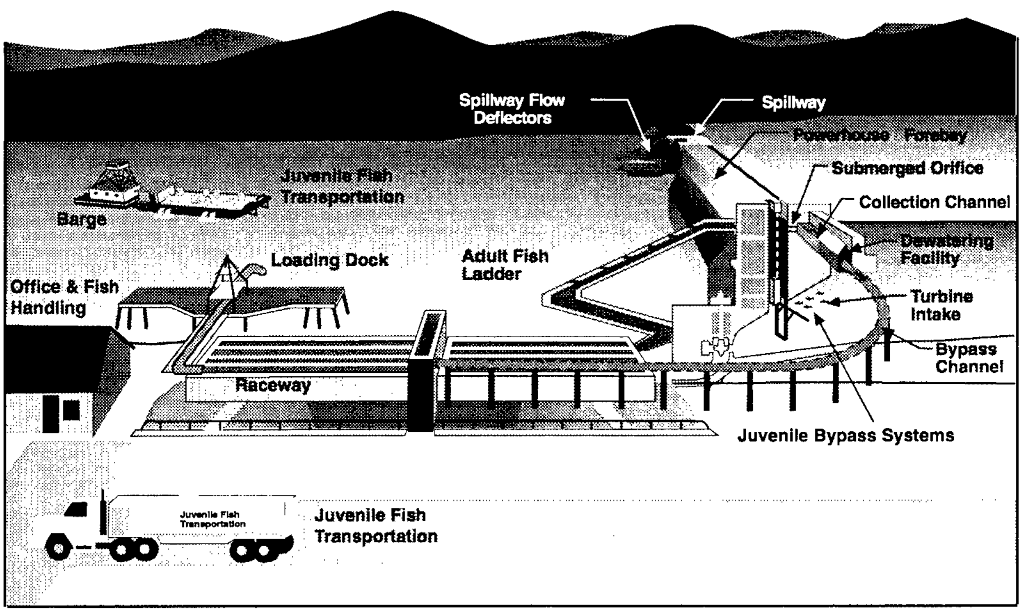


Figure 2-2a. Existing Fish Passage Systems

In 1987, the Columbia River Fish Mitigation Program (CRFMP) was initiated. Under this program, juvenile fish bypass/collection facilities were upgraded at Ice Harbor (1996), Lower Monumental (1993), and Little Goose (1998). Other improvements such as spillway flow deflectors at Ice Harbor and ESBS at Little Goose and Lower Granite,

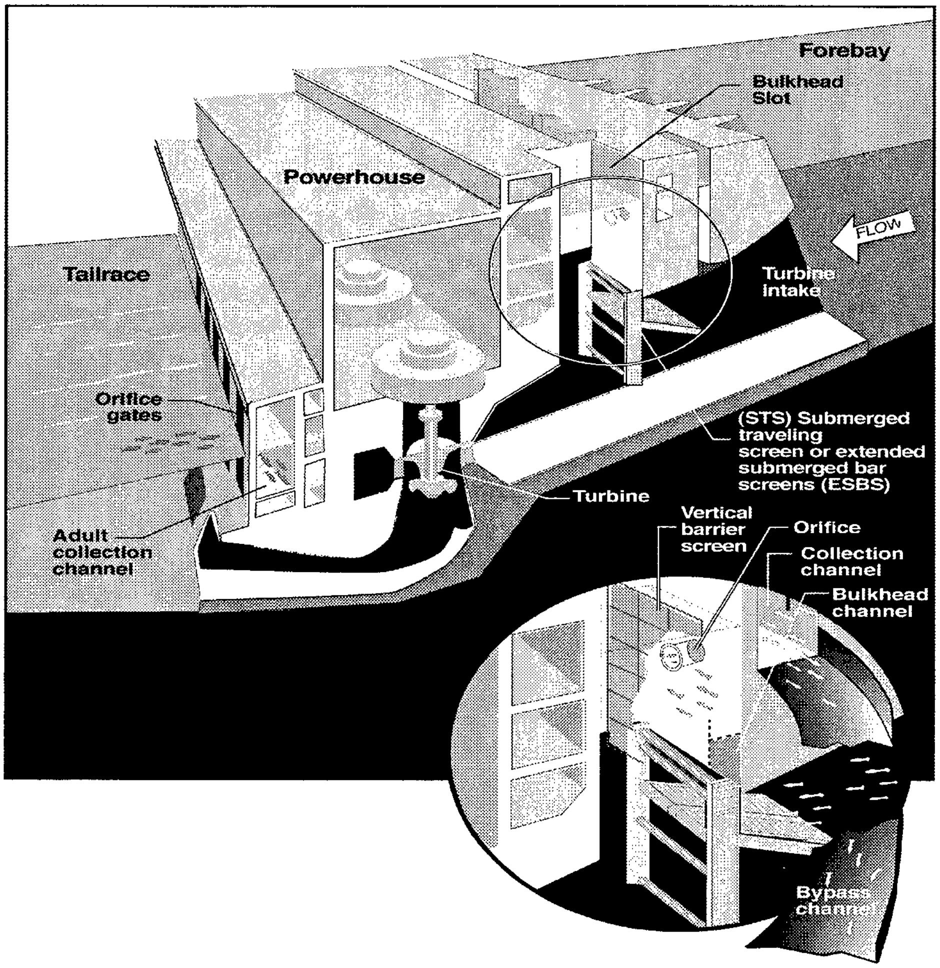


Figure 2-2b. Juvenile Fish Bypass Facilities

have also been added. Also, studies are underway to investigate ways to improve water quality (i.e., lower temperature) in the ladders.

The fish agencies and tribes recommended postponing the upgrade of the Lower Granite facilities, pending the decision on this FR/EIS. Although, at this time, the existing facilities at Lower Granite provide high survival (99.5 percent), numerous studies have shown substantial stress occurs in fish that pass through the bypass system. However, the cost of replacing the facilities to eliminate these known stress problems would be lost if a decision is made to breach the dam. Therefore, if the decision is to continue current operations, replacing this facility would be an element of that action. Specific plans for upgrading the Lower Granite juvenile fish facility are presented in Technical Appendix E, Existing Systems and Major System Improvements Engineering.

Current measures for collection and transportation of juvenile fish outmigration are identified in the 1995 Biological Opinion, 1998 Biological Opinion, and the Endangered Species Act (ESA) Section 10 Permit (#895) for the Juvenile Fish Transportation Program (JFTP). The Corps operates the JFTP in cooperation with NMFS and in accordance with the 1995 and 1998 Biological Opinions.

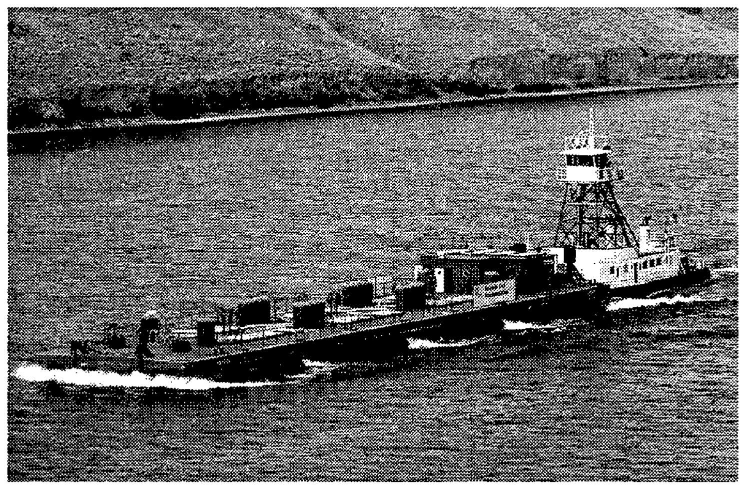
Typical existing facilities for juvenile fish (Figure 2-2b) that enter the turbine area (compared to those that would pass over the spillway) include the following:

- **Turbine Intakes**—Each generating unit at the lower Snake River dams has three turbine intakes. These intakes are similar at all four dams except that they are slightly smaller at Ice Harbor.
- **Turbine Intake Screens**—Standard length submerged traveling screens (STSs) are devices that are lowered into the turbine bulkhead slots to divert fish from the turbine intake. The screened area is 20 feet high and 20 feet wide. The screen is a continuous belt that travels around the frame like a conveyor belt. The screen revolves so that debris collected on the front face is carried over to the back side where it is washed off by the flow through the screen. STSs are used at Lower Monumental and Ice Harbor. STSs were replaced with ESBSs at Lower Granite (1996) and Little Goose (1997). The ESBSs are 40 feet long and 20 feet wide.
- **Bulkhead Channel**—Fish guided into the bulkhead slot swim or are carried upward by the flow deflected by the fish screen. Fish not deflected by the screen pass through the turbine.
- **Collection Channel**—The fish move through an orifice into the collection channel within the powerhouse. At Lower Granite, a collection channel was constructed in the dam and became operational in 1975. Little Goose and Lower Monumental were constructed with imbedded pipelines for juvenile bypass systems. Subsequent modifications at Little Goose (in 1984 and 1985) and Lower Monumental (1991) resulted in mining of tunnels similar to the collection channel at Lower Granite. At Ice Harbor, a collection channel was constructed in the ice/trash sluiceway along the upper face of the powerhouse in 1995.
- **Bypass Channel**—Fish are directed through a bypass pipe or flume to the fish collection/handling facilities (see Figures 2-2a and 2-2b).
- **Fish Collection/Handling**—Fish arriving at the juvenile fish facilities by pipe or flume are separated from adult fish and debris by a separator. They are then passed to holding ponds or raceways where they are held until being loaded into a truck or barge.
- **Transportation**—Juvenile fish are transported under the guidelines of the Fish Passage Plan and the Corps' JFTP. Juvenile fish are not transported at Ice Harbor, but the majority are bypassed directly to the tailrace below the dam. At Lower Granite, Little Goose, and Lower Monumental, juvenile fish that go through the bypass systems can be routed either directly back into the river below the dam, or to holding and loading facilities for loading into barges or trucks for transport.

Trucks are used for transport when the number of fish collected is 20,000 or fewer per day at Lower Granite.

The transport barges and trucks carry the fish past the remaining projects in the Columbia-Snake River System for release below Bonneville Dam. River water circulates through the barges, allowing the fish to imprint the chemicals and smells of the water during the trip downriver. Similarly, trucks are specially equipped to maintain proper conditions during transport (e.g., operation and maintenance of water temperatures). The adults use this "imprinting" mechanism during upstream migration to guide them to the location where they originated (e.g., spawning area or hatchery).

Collection of juvenile fish generally starts March 25 at Lower Granite and a few days later at Little Goose and Lower Monumental. There are currently eight barges in the Corps' fish passage fleet. Early in the season (typically the second week in April), a barge leaves Lower Granite every other day. As numbers of fish increase, barging is increased to every day. In order to follow the "spread-the-risk" policy described in the 1995 and 1998 Biological Opinions, the current goal is to transport about half of the juvenile Snake River salmon and steelhead. The remainder are either bypassed back to the river, pass through the turbines, or may pass over the spillway if spill occurs.



2.1.3 Reservoir Operation Levels

Drawing down the reservoirs to increase water velocity and decrease travel time of downstream migrating juvenile salmon was first considered in the late 1980s. As identified in the 1995 and 1998 Biological Opinions, NMFS requested operation of the lower Snake River reservoirs at minimum operating pool (MOP) from about April through August. This level is considered the bottom one foot of the operating range for each reservoir. The reservoirs normally have a 3-foot or 5-foot operating range.

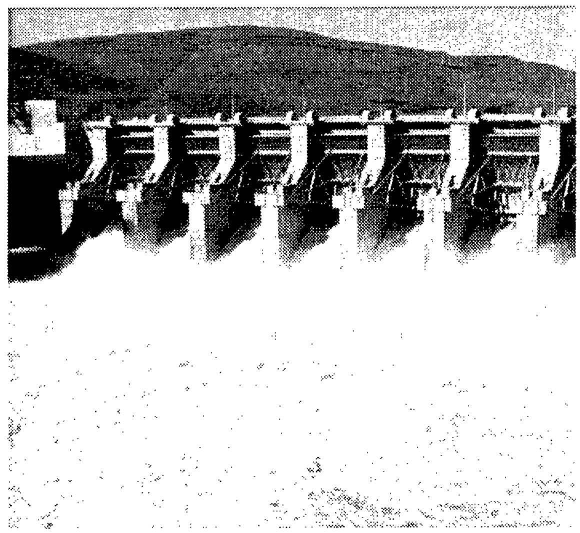
2.1.4 Turbine Operation

Historical studies demonstrated that operating turbines within one percent of peak efficiency would maximize survival of juvenile salmon passing through the turbines (Bell, 1990). Since the mid-1980s, the Corps has made every effort to operate turbines at the four dams within the one percent peak efficiency rate. In its listing of the Snake River salmon in 1991 and 1992, and under the 1995 Biological Opinion, NMFS requested that the Corps operate turbines within one percent of peak efficiency during juvenile and adult migration seasons, which extends from March 15 to November 30 on the lower Snake River.

Studies following this operational change have shown turbine mortality to be less than 7 percent (Normandeau Associates, et. al, 1996; Normandeau Associates, Inc. and Skalski, 1997) at each dam. Studies prior to this operational change typically showed about 15 percent mortality to juvenile salmon from passage through turbines at each dam (Bell, 1990).

2.1.5 Spill for Juvenile Passage

As previously mentioned, the Lower Snake River Project facilities are run-of-river and provide little storage of water. Therefore, when reservoirs are full and flows exceed the capacity of the powerhouse or power output needs, water is involuntarily spilled. In contrast, voluntary spills would be those that are not required to pass excess flows downstream (e.g., the powerhouse could pass the flows and there is sufficient power demand). Voluntarily passing water over dam spillways rather than through the powerhouse is an operations approach used to divert juvenile fish from the turbines as they approach a dam. The majority of spill occurs at night.



The Corps began spilling water for juvenile salmon at several Lower Snake projects in 1977, as a way of improving juvenile fish passage survival. A more comprehensive spill program was initiated in 1989, when a long-term spill agreement was signed by BPA, the fisheries agencies, tribes, and others (BPA et. al., 1995). The Corps considers the spill requests each year when determining operations of its dams.

In response to the 1995 and 1998 Biological Opinions, spill at the dams has been increased substantially during juvenile fish migrations. However, spill has associated risks, because spilling water can entrain air when the water plunges into the spillway basins, causing raised levels of dissolved gas in the water that can be harmful to fish (dissolved gas supersaturation). In addition, when spill occurs, fish that could be collected and transported around a series of dams are bypassed downstream to the next reservoir and whatever dams are left to pass. Therefore, the spread-the-risk policy in the 1995 and 1998 Biological Opinions was adopted to allow multiple ways of passing juvenile fish downstream (i.e., fish are either passed over the spillway into the tailrace, bypassed around the dam and transported by truck or barge, or are bypassed around the dam and released below the tailrace). Under the existing operations, spill is limited to the adjusted total dissolved gas "cap" (see Section 4.5, Aquatic Resources) as administered by the states of Oregon and Washington. The largest concentrations allowed are 115 percent in the forebays and 120 percent in the tailwaters.

2.1.6 Completion of Gas Abatement Measures

Dissolved gas supersaturation emerged as a major threat to the survival of the Snake River and Columbia River salmon runs in the late 1960s. In response, the Corps initiated a major effort to modify Corps' dams to reduce the problem. Measures taken were:

1) completion and use of upstream storage to minimize spill, 2) installation of turbines in skeleton bays (unused turbine bays) at the lower Snake River and Columbia River dams, and 3) installation of spillway flow deflectors in the spill bays at the lower Snake River and Columbia River dams.

Spillway flow deflectors (Figure 2-3) produce a more horizontal spill flow that limits the plunge depth of water over the dam spillway. This reduces the amount of total dissolved gas, but high spill levels can diminish the effectiveness of the flow deflectors. Spillway flow deflectors are installed in all eight spillway bays at Lower Granite. Deflectors were installed in six of eight bays at Little Goose and Lower Monumental. Studies by fishery agencies indicated that deflectors should not be added in the end bays because of concerns relating to the tailrace hydraulic conditions in the immediate vicinity of adult fish ladder entrances. These localized conditions could delay adult fish from finding the ladder entrances.

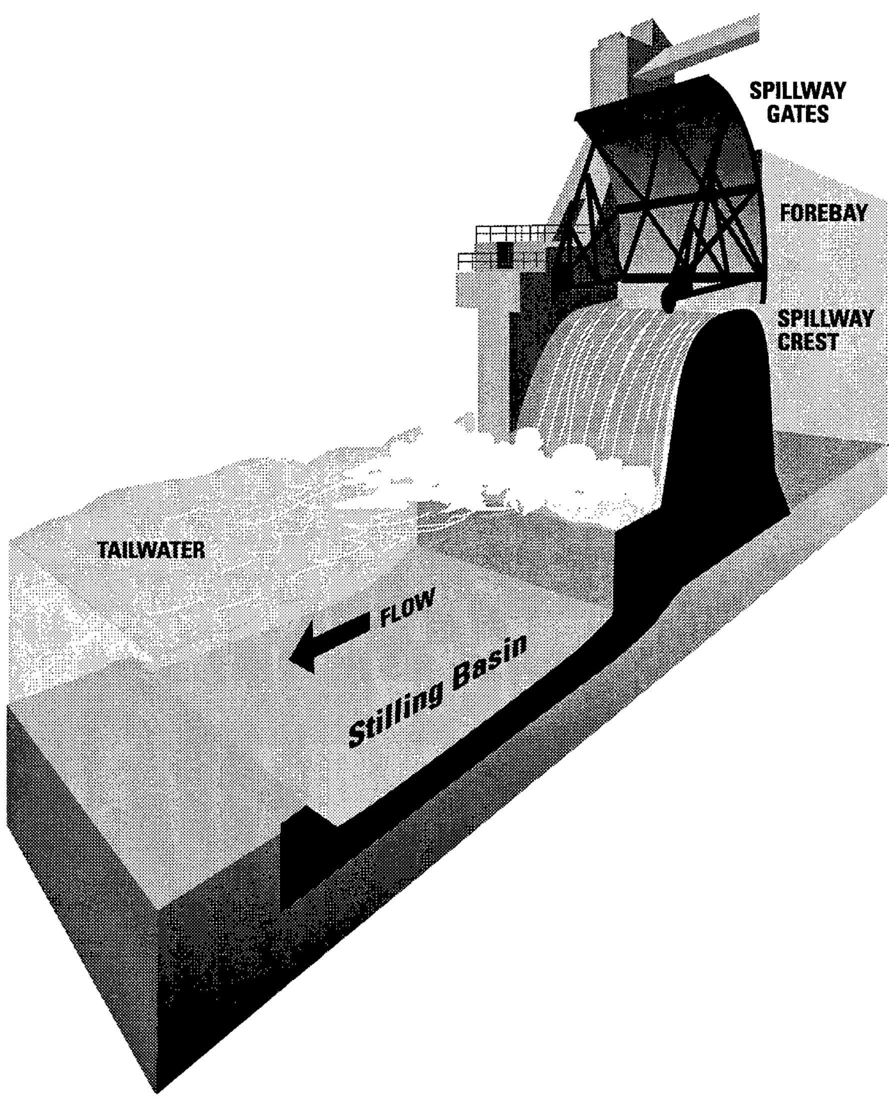


Figure 2-3. Spillway Flow Deflector (flip lip), Lower Granite Dam Spillway

Spillway flow deflectors originally were not installed at Ice Harbor because of concerns over adult fish passage, and because it was only a few miles to low supersaturated waters in the Columbia River coming from the free-flowing Hanford Reach. In 1996 and 1997, spillway flow deflectors were added to 8 of the 10 spillway bays at Ice Harbor as a result of increased spills to accommodate the requests made by NMFS in the 1995 Biological Opinion, which included keeping a portion of the downstream migrating fish in the river (versus transport) as part of the spread-the-risk policy. This action raised the spill cap from about 25 thousand cubic feet per second (kcfs) to about 75 kcfs at 120 percent gas concentrations, which benefited fish passage efficiency (FPE) (see Section 5.4, Aquatic Resources). In 1997 and 1998, flow deflectors were installed in the two remaining spillway bays along with an added training wall which raised the spill cap (i.e., the maximum amount of spill that results in the highest allowed total gas concentration) from about 75 kcfs to about 105 kcfs at 120 percent gas concentrations. Studies are continuing on structural measures to reduce total dissolved gas production as well as on total dissolved gas effects on juvenile fish mortality. These structural measures include potential installation of spillway flow deflectors in bays where they have not yet been installed, raising stilling basins, and installing alternate methods of passing water. Under existing conditions, additional deflectors, modifications to existing spillway flow deflectors, and other structural modifications would be added at Lower Granite, Little Goose, and Lower Monumental. Additional deflectors and a pier extension (to more effectively control the downstream flow patterns of spilled water) have already been added at Ice Harbor.

Monitoring of dissolved gas concentrations has greatly advanced in the past 30 years. With the existing operations, a network of monitoring stations has been established above and below each dam, and at other major sites throughout the FCRPS. This network provides the Corps, the Fish Passage Center (a technical office of the Columbia Basin Fish and Wildlife Authority [CBFWA]), and NMFS with immediate access to dissolved gas information throughout the system. Under existing conditions, this monitoring of dissolved gas concentrations would continue.

2.1.7 Flow Augmentation

Dams upstream of Lower Granite can regulate water for flood control, irrigation, and other uses, interrupting the seasonal river flow patterns in downstream areas. Flow augmentation (i.e., increasing river flows above levels that would occur under normal operation by releasing more water from storage reservoirs) can aid migration of juvenile salmon. The original Fish and Wildlife Program of the Northwest Power Planning Council (NPPC) (NPPC, 1982) included an amount of upstream storage to be controlled by the fishery agencies and tribes. This water (termed the "Water Budget") was used to simulate the natural spring freshet for the juvenile salmon outmigration. The increased

flow is presumed to help flush fish downriver and reduce their exposure to predators and other potential hazards in reservoirs.

The Fish Passage Center was established to manage the Water Budget, which includes water releases from Dworshak plus additional water from the Hells Canyon complex and the upper Snake River. The amount and timing of release for the Water Budget were determined each year, based on the amount of water potentially available in storage.

Following the listing of Snake River sockeye salmon in December 1991 and spring/summer chinook and fall chinook in April 1992, NMFS released a series of Biological Opinions (NMFS, 1995). The 1995 Biological Opinion changed the operating regime for flow augmentation volumes to target flows at Lower Granite. A Technical Management Team (TMT) was established to advise the operating agencies on dam and reservoir operations to optimize passage conditions for juvenile and adult anadromous salmonids. The TMT is consists of representatives from NMFS, USFWS, BOR, Corps, BPA, states, and tribes. It meets weekly during the juvenile fish migration seasons to discuss flows and spills, and to plan operations for fish.

All TMT recommendations are made to the Corps and BOR, which have authority to operate the FCRPS projects, and to the Corps and BPA, which have the authority to make agreements with Canada regarding storage in Canada (for mainstem Columbia River projects).

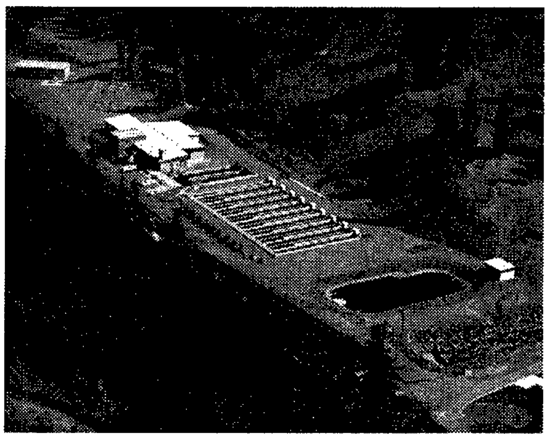
The 1995 Biological Opinion called on the BOR to provide 427 thousand acre-feet (KAF) of water for flow augmentation by acquiring water supplies from willing sellers in the middle and upper Snake River Basin. BOR has provided these flows each year by leasing or acquiring water supplies and by releasing water from uncontracted storage space in BOR-owned reservoirs. The Idaho statute that authorized release of the additional 427 KAF will expire on January 1, 2000. This statute covers only the release of water from storage (not natural flows) and specifies that the amount of flow augmentation that BOR can provide from all sources is limited to 427 KAF in any year.

In addition to the 427 KAF, Idaho Power Company also provides spring/summer storage releases from Brownlee Reservoir of about 237 KAF. Also during the summer period, the Corps releases about 1.2 million acre-feet (MAF) from Dworshak Reservoir. From these three entities (BOR, Idaho Power, and Corps), approximately 1.9 MAF of Snake River Basin storage is made available for augmentation.

The 1995 Biological Opinion recommended that BOR pursue the acquisition of additional water after 1998 if necessary to contribute to the survival and recovery of listed fish species. The 1998 Biological Opinion did not change this request. The 1998 Biological Opinion did, however, request that studies be conducted to evaluate an increase in flow above the 1995 amount, perhaps by another 1.0 MAF. BOR has conducted the study of the effects of providing 1.0 MAF, but no actions have been authorized or implemented because, based on initial study findings, the 1.0 MAF option did not meet Federal criteria for completeness and public acceptability. In addition, the acquisition of this much water was not considered as reasonably foreseeable in the future (BOR, 1999).

2.1.8 Lower Snake River Fish and Wildlife Compensation Plan

The *Lower Snake River Fish and Wildlife Compensation Plan* (Comp Plan) was authorized by the Water Resources Development Act of 1976 to mitigate for fish and wildlife losses caused by construction and operation of the four lower Snake River dams. The Comp Plan consists of fish hatcheries, satellite fish facilities, a fish laboratory, wildlife habitat areas and development areas, and lands with fishing and hunting access. The facilities and lands of the Comp Plan are primarily located in the upper, middle, and lower subbasins of the Snake River Drainage, in Washington, Oregon, and Idaho. The remaining facilities and lands are located in the upper Columbia, Yakima, and Mid-Columbia subbasins. Some facilities are located on existing Federal lands, but the majority are deeded lands and easements.



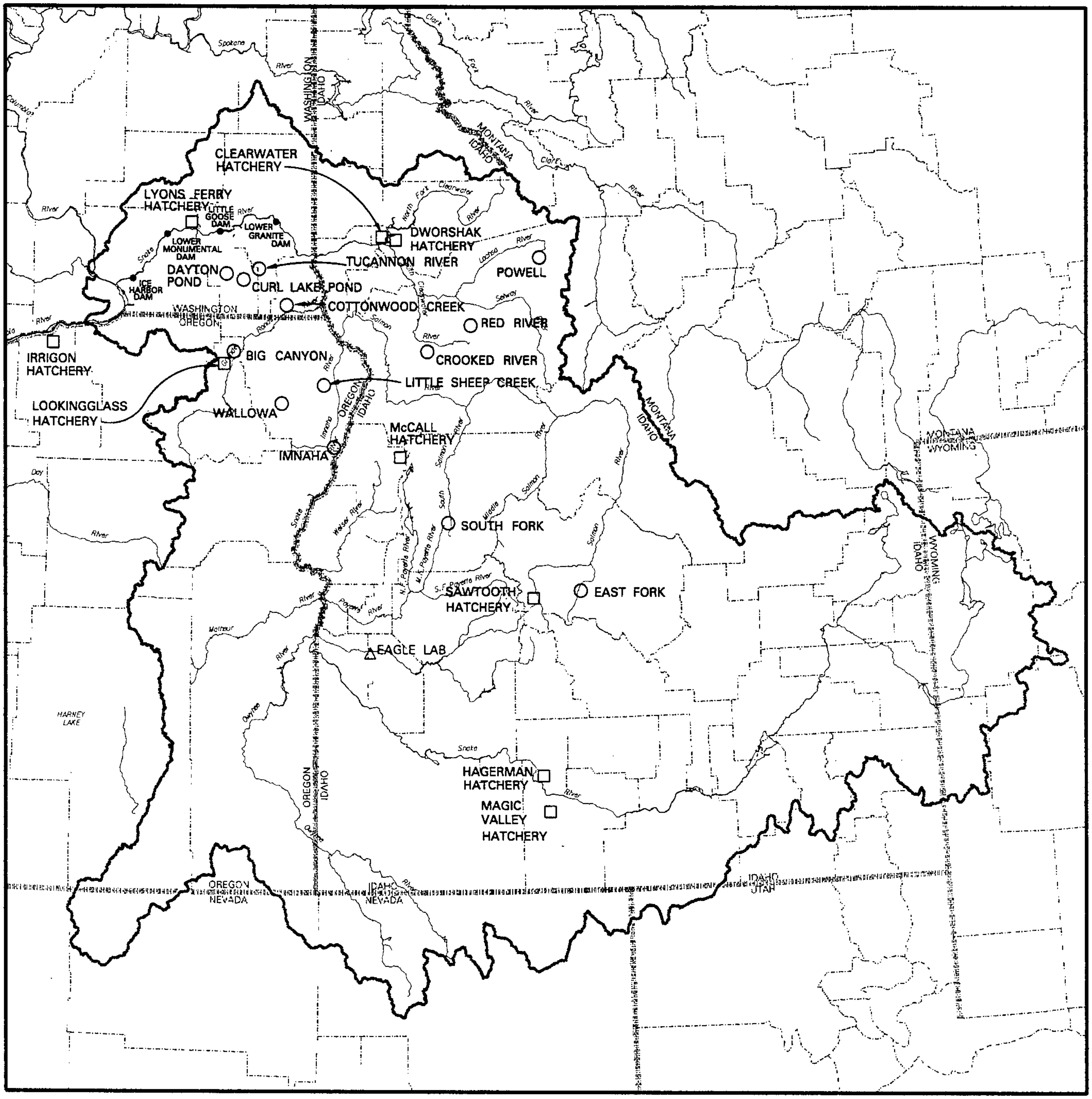
The hatcheries developed under this plan were designed to produce about 28 million juvenile spring, summer, and fall chinook salmon, and steelhead as well as any other stock in need of supplementation. Eleven hatcheries were modified or constructed along with a number of collection facilities for gathering adults, and acclimation ponds for acclimating juveniles to water sources where they would return as adults (Figure 2-4). These facilities are operated by state fisheries agencies or USFWS. Recently, additional acclimation facilities have been constructed by the Corps and are operated by the Nez Perce Tribe and the Confederated Tribes of the Umatilla Indian Reservation. In addition, the listing of sockeye salmon resulted in a captive broodstock program funded by BPA. Also, the Nez Perce Tribe has been transporting coho salmon from the lower Columbia River to the Clearwater Basin in an attempt to re-establish runs of these species.

The Comp Plan includes a large number of Habitat Management Units (HMUs) that were developed as mitigation for the loss of habitat associated with the four dams and reservoirs (Figure 2-5). These were developed for a wide variety of habitat and species. HMUs range in size from less than 1 acre to over 3,000 acres. Initially, they were developed on existing project lands and subsequently, additional lands were purchased and leased for mitigation both along the lower Snake River or up to 100 miles or more from the river. Table 2-3 summarizes the number and area of HMUs for each dam.

Further detailed discussion of the HMUs is provided in Section 4.6, Wildlife, and in Technical Appendix L, Lower Snake River Mitigation History and Status.

2.1.9 Surface Bypass Collector Prototype Operation

The existing juvenile bypass facilities are constantly being evaluated and improved by scientists and engineers. For example, since 1996 a prototype surface-oriented bypass and collection system has been under evaluation by the Corps at Lower Granite. The system is designed to collect downstream migrating juveniles in the forebay and safely bypass them either over the dam or transport them downstream in trucks or barges (see Section 2.1.2, Juvenile Fish). A final design surface bypass collector (SBC) would be



SATELLITE ○

Satellite	
South Fork	A
East Fork	B
Wallowa	C
Big Canyon	D
Imnaha	E
Little Sheep Creek	F
Dayton Pond	G
Curl Lake Pond	H
Tucannon River	I
Cottonwood Creek	J
Red River	K
Crooked River	L
Powell	M

HATCHERY □

Hatchery Name	Associated Satellite
McCall Hatchery	A
Magic Valley	B
Hagerman Hatchery	B
Lookingglass Hatchery	E
Irrigon Hatchery	C,D,F
Lyons Ferry Hatchery	G,H,I,J
Dworshak Hatchery Expansion	A
Sawtooth Hatchery	*(None)*
Clearwater Hatchery	K,L,M

FISH DISEASE LABORATORY △

DISTRICT BOUNDARY

KM 70 35 0 MILES 35 70

490,000 ACRES

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

1 : 53,222,400

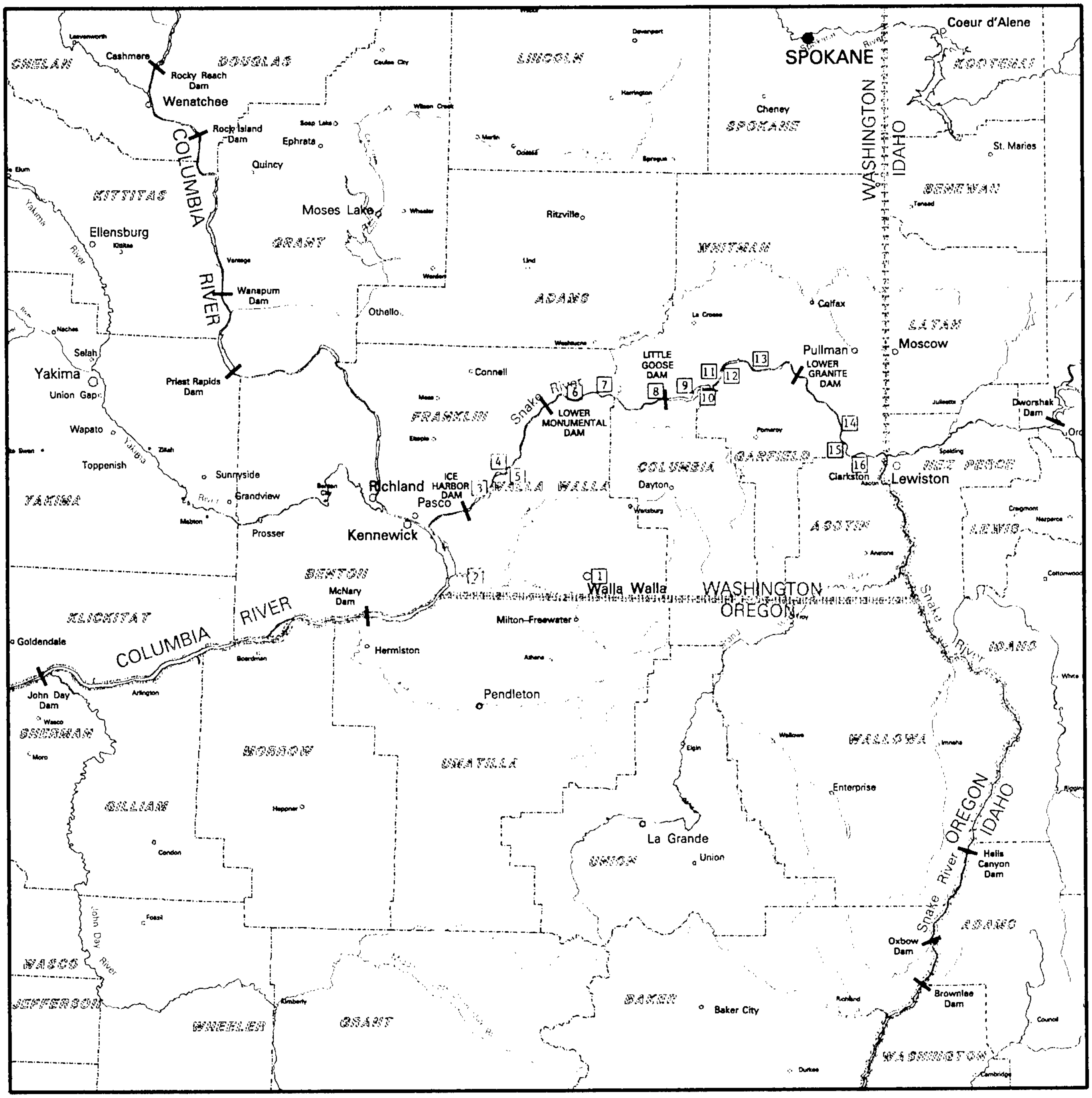
DRAFT

Lower Snake River
Juvenile Salmon Migration Feasibility Study

Figure 2–4.
REGIONAL HATCHERIES

GIS Analysts & Graphic Assembly: Applied Technology Team (CENWW-PM-PD-E)
g:\regional\reg\plates\lsr\jsmeis\lsrg\lsrghatc.dgn:GISFILE PLOTTED: 06 DEC 1999

1999



HABITAT MANAGEMENT UNITS (HMU)

Mill Creek FWWTR HMU	1	Ridpath HMU	9
Wallula HMU	2	New York Bar HMU	10
Big Flat HMU	3	Central Ferry HMU	11
Lost Island HMU	4	Willow Bar HMU	12
Hollebeke HMU	5	Swift Bar HMU	13
Skookum HMU	6	Nisqually John HMU	14
Fifty-Five Mile HMU	7	Kelly Bar HMU	15
John Henley HMU	8	Chief Timothy HMU	16

KM 300 100 0 MILES 7.5 15 30

125,000 ACRES

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

1 : 1,900,800

DRAFT

Lower Snake River
Juvenile Salmon Migration Feasibility Study

Figure 2-5.
REGIONAL HABITAT MANAGEMENT UNITS

PLOTTED: 06 DEC 1999

1999

Table 2-3. Number of HMUs per Facility

Dam	No. of HMUs	Total Acres
Ice Harbor	14	2,032
Lower Monumental	13	4,381
Little Goose	18	3,019
Lower Granite	17	5,002
Total	**62**	**14,434**

designed to attract juvenile fish prior to diving and encountering the existing turbine screening bypass system (Corps, 1996b). The basis for the SBC design was the successful surface-oriented bypass system currently in use at Wells Dam on the mid-Columbia River. At Wells Dam, the spillways are located on top of the submerged powerhouse turbines, causing a surface bypass effect. Fish are attracted to the current created by the turbines, but instead, pass over the spillway rather than diving to the turbine openings. At Corps-operated dams, the spillways are next to, rather than over, the powerhouse.

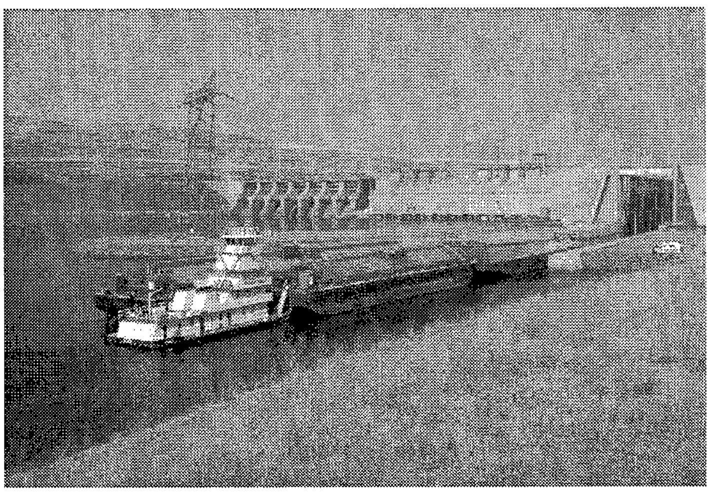
In 1998, modifications were made to the Lower Granite prototype to effectively make the collector deeper and to include a behavioral guidance structure (BGS) to guide fish to the SBC entrance. The tests for the prototype SBC would continue for a limited time under existing conditions. Test results to date have indicated that as a "stand-alone" fish diversion system (i.e., without screens), the SBC would divert about 62 percent of the fish away from turbines. In combination with intake screens, a SBC system would divert over 90 percent of the fish away from the turbines; roughly a 10 percent increase over the present screen systems. In a combined screen and SBC system, roughly two-thirds of the diverted fish would also gain the benefits of a SBC system (i.e., more passive and benign flow conditions with less passage delays). Additional testing of the Lower Granite SBC prototype is tentatively planned for 2000 and 2001. SBC technology gained from this testing may be used in potential future applications on the Lower Snake River and at other surface collector projects in the region.

2.1.10 Power Marketing

The integrated system of 30 Federal hydroelectric facilities in the Columbia River Basin, on average, accounts for approximately 60 percent of total regional energy and 70 percent of total electrical generating capacity. The four dams in the Lower Snake River Project have a total nameplate capacity of 3,033 megawatts (MW) (Table 2-4) or about 5 percent of the total regional energy or 7 percent of the total electrical generating capacity. When there is a surplus of hydropower, it is an important export product for the region. BPA markets and distributes the power generated by the Corps and BOR at the Federal dams in the Columbia River Basin, including power generated by the four dams on the lower Snake River. The power is sold to public and private utilities in the region, utilities outside the region, and some of the region's largest industries. Power lines originate at generators at the dams and extend outward to form key links in the regional power transmission grid. BPA owns and operates the transmission system. The Northwest grid is interconnected with Canada to the north, California to the south, and Utah and other states to the east. Power produced at dams in the Pacific Northwest is provided to customers both locally and thousands of miles away.

2.1.11 Navigation

The 465-mile Columbia-Snake Inland Waterway represents a key link to the Columbia-Snake River Basin interior region. It facilitates barge transport from the Pacific Ocean to Lewiston, Idaho, the most inland port. This transportation system consists of navigation channels and locks, port facilities, and shipping operations (see Table 2-4). The system is used for commodity shipments from inland areas of the Pacific Northwest and as far away as North Dakota. The lower Snake River is part of the shallow draft portion of the waterway. The Corps maintains a navigation channel 250 feet wide and 14 feet deep from the mouth of the Snake River to the confluence of the Snake and Clearwater rivers. The navigation channel accommodates tugs, numerous types of barges, log rafts, and recreational boats and connects the interior of the basin with deep water ports on the lower Columbia River. Grain is the primary commodity transported on the lower Snake River.



2.1.12 Recreation

There are 33 developed recreation sites adjacent to the lower Snake River reservoirs. These include 28 boat ramps with 59 launch lanes, 5 moorage and marina facilities, 9 campgrounds with approximately 422 individual campsites, and 49 day-use facilities. Most of these sites are located in rural areas removed from population centers. Exceptions include the sites at Ice Harbor, which are close enough to be used by residents of the Tri-Cities, and sites at Lower Granite near the Lewiston-Clarkston area. Several of the larger developed sites were constructed by the Corps and are operated by counties, states, or port districts under lease. The details of recreation aspects of the Lower Snake River Project are discussed in Section 4.12, Recreation and Tourism.

2.2 Facility Operations and Structures

The following sections discuss specific operations and structures at each of the hydropower facilities in turn, proceeding downstream from Lower Granite. Summary information for each facility is provided in Table 2-4. Detailed descriptions of fish facilities (Section 3.1, Alternative 1— Existing Conditions), park and recreation facilities (Section 4.12, Recreation), and wildlife habitat (Section 4.6.2, Wildlife) are provided in their respective sections. The four main features (powerhouse, spillway, navigation lock, and non-overflow embankment) common to all four dams are shown on Figure 2-6.

Table 2-4. Facility Operations and Structures

	Lower Granite	Little Goose	Lower Monumental	Ice Harbor
Reservoir				
Normal Operating Pool (feet above msl)	738	638	540	437
Total Length (miles)	43.9	37.2	28.7	31.9
Length of Shoreline (miles)	92	93	86	83
Average Width (miles)	0.3	0.4	0.4	0.4
Surface Area (acres) 1/	8,448	10,825	4,960	9,002
General (Dam)				
Dam Length (feet)	3,200	2,655	3,791	2,822
Hydraulic Head (feet)	100	98	100	100
Powerhouse				
Powerhouse Length (feet)	656	656	656	671
Nameplate Capacity (MW)	810	810	810	603
Total Number of Units Installed	6	6	6	6
Spillway				
Spillway Length (feet)	512	512	498	590
Number of Spillway Bays	8	8	8	10
Stilling Basin Length (feet)	188	118	180	168
Navigation Lock and Channels				
Lock Chamber Length (feet)	675	668	650	675
Lock Chamber Width (feet)	86	86	86	86
Maximum Operating Lock Lift (feet)	105	101	103	105

msl = mean sea level

1/ At normal operating pool elevation (highest level of range)

Source: Corps 1999c

2.2.1 Lower Granite

Lower Granite is located on the Snake River at river mile (RM) 107 near Almota, Washington (Figure 2-6). The project is named after Granite Point, a rock formation 6 miles upstream from the dam. This rock outcropping is the only granite formation in an area of generally dark basalt. Lower Granite Lake extends 39.3 miles upstream on the Snake River and a further 4.6 miles on the Clearwater River. Lewiston, Idaho is located 33 miles upstream of the dam. Lower Granite was placed into service in 1975. Lower Granite has five major components (Figure 2-7). From the south (right bank) to north (left bank), they are the fish passage facilities, powerhouse, spillway, navigation lock, and non-overflow embankment. The dam, located at the head of Lake Bryan, is 3,200 feet long, with an effective height of 100 feet. The normal operating range of Lower Granite Lake (the reservoir) extends from 733 to 738 feet above mean sea level (msl). The powerhouse is 656 feet long and 243 feet wide, and houses six 135-MW generators. Next to the powerhouse is a 512-foot-long concrete spillway equipped with steel tainter gates. The spillway has eight spill bays, each 50 feet wide. The tainter gates are each 50 feet wide by 60 feet high. A concrete-lined stilling basin extends 188 feet downstream from the spillway along the river bottom. The navigation lock at Lower Granite is a single-lift type, 675 feet long by 86 feet wide, with a 15-foot minimum depth and a maximum lift of 105 feet. Next to the navigation lock is the north dam embankment,

which is 756 feet long. This embankment is an earthfill structure with an impervious core. The core is protected both upstream and downstream by sand and gravel filter zones flanked by gravel shells. The upstream slope of the embankment is armored with riprap from elevation 756 feet down to 719 feet; below 719 feet, smaller rock fill provides bank protection.

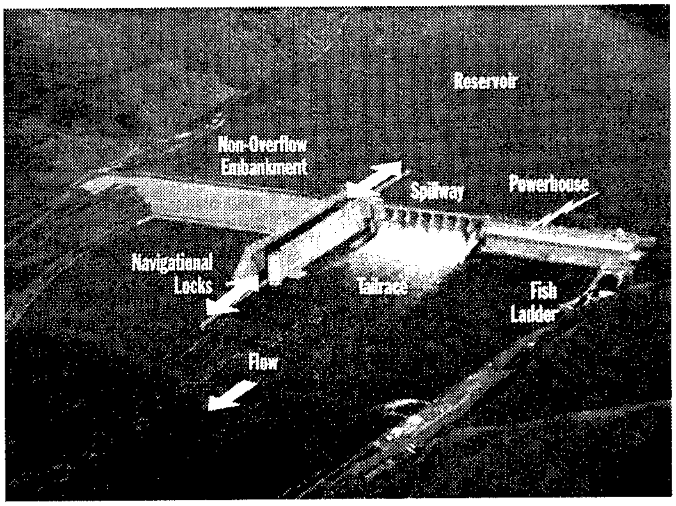


Figure 2-6. Looking Upstream at Lower Granite Facility

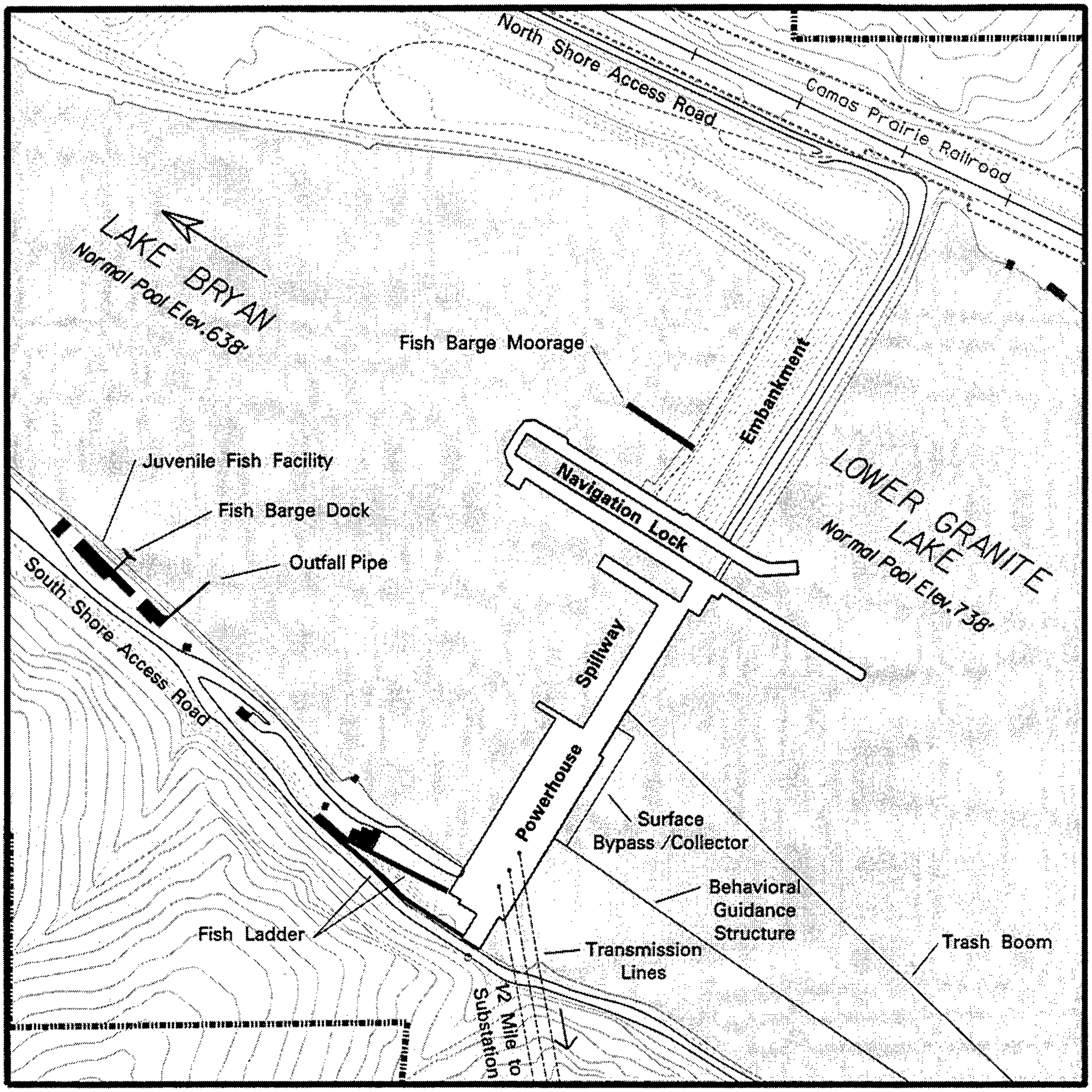
Juvenile fish passage facilities at Lower Granite consist of a bypass system and transportation facilities (see Table 2-2 and Sections 2.1.1, Adult Fish, and 2.1.2, Juvenile Fish). Adult fish passage facilities are composed of one fish ladder on the south shore, a powerhouse collection system, and an auxiliary water supply system. Components of the juvenile and adult fish passage facilities are presented in Table 2-2.

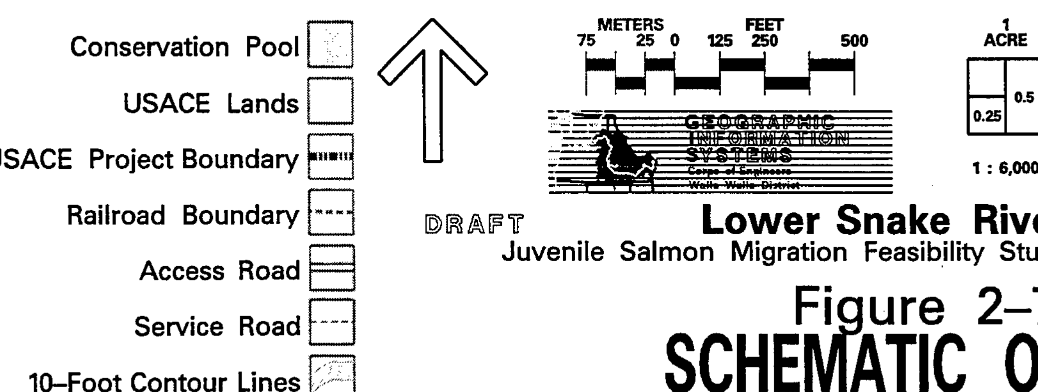
There are 9,220.4 acres of project lands surrounding Lower Granite Reservoir. These lands include fee lands that are Federally owned and managed by the Corps, as well as easement lands on which the Corps has designated rights (i.e., flowage or access). Approximately 515 acres are leased either to state or local public agencies. Port districts own lands adjacent to the project for industrial development. The majority of these project lands, 4,801.6 acres, are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development.

There are 13 developed recreation areas adjacent to Lower Granite Reservoir. These include 12 boat ramps with 28 launch lanes, 2 moorage/marina facilities, 12 day-use facilities, and 3 campgrounds with a total of approximately 168 individual campsites.

Land surrounding the reservoir is also managed by the Corps for wildlife habitat enhancement. HMUs were established along the lower Snake River to compensate for wildlife habitat lost as a result of inundation by the Lower Snake River Project. There are 17 HMUs, totaling 5,002 acres, along Lower Granite Reservoir. Water pumped from the reservoir is used to irrigate one of these HMUs.

Water is withdrawn from Lower Granite Reservoir by six municipal and industrial pump stations. The water is used for municipal water system backup, golf course irrigation, industrial process water for paper production and concrete aggregate washing, and park irrigation. Two additional stations owned by Asotin Public Utility District (PUD) #1 have not been operated over the past few years and no plans exist to operate them in the immediate future.





DRAFT

Lower Snake River

Juvenile Salmon Migration Feasibility Study

Figure 2-7.

SCHEMATIC OF LOWER GRANITE FACILITY

1999

GIS Analysts & Graphic Assembly: Applied Technology Team (CENWW-PM-PD-E)
g:\regional\reg\plates\lsr\lsrlladv.dgn:GISFILE PLOTTED: 06 DEC 1999

There are three port facilities on Lower Granite Lake (Lewiston, Clarkston, and Wilma). They are used for grain, wood products, and other commodities. The port at Wilma is capable of handling petroleum products.

2.2.2 Little Goose

Little Goose Dam (Figure 2-8) is located on the Snake River at RM 70.3 near Riparia, Washington. The facility is named after an upstream island that was inundated following completion of the dam. Little Goose Reservoir, known as Lake Bryan, extends 37.2 miles upstream to Lower Granite. Little Goose was placed into service in 1970.

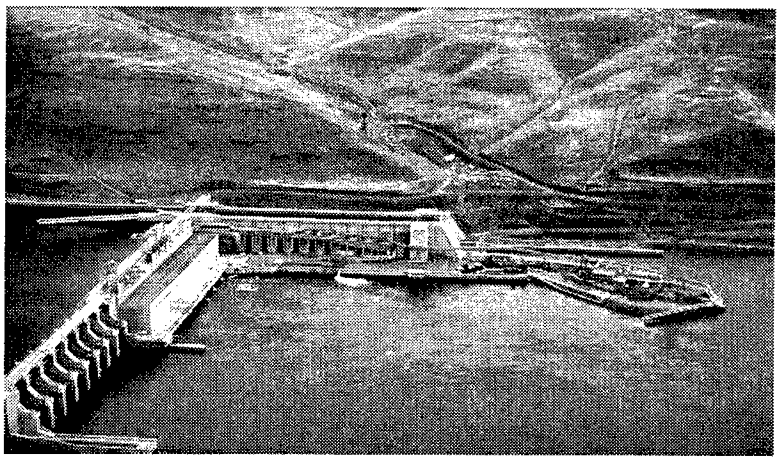
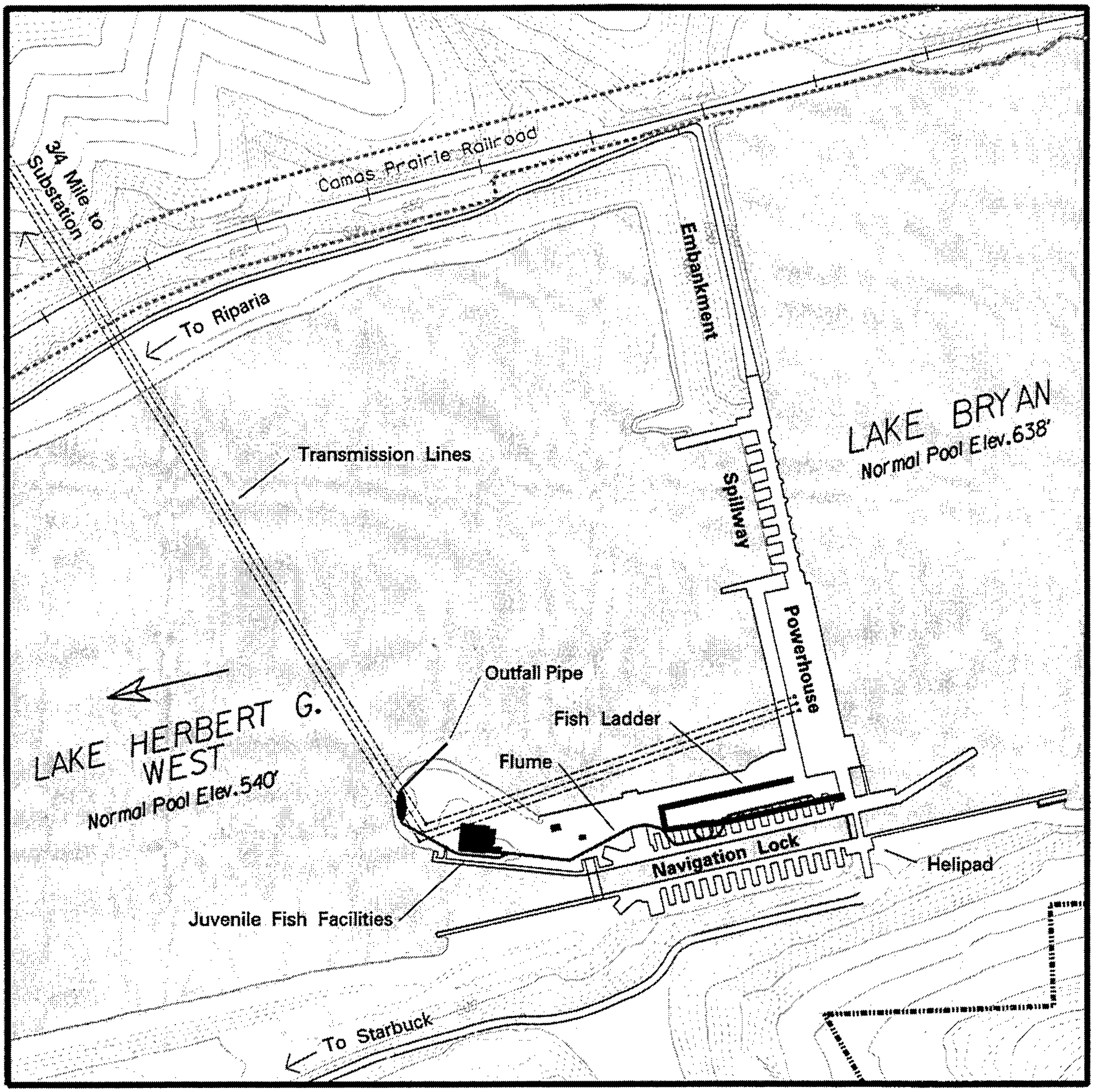


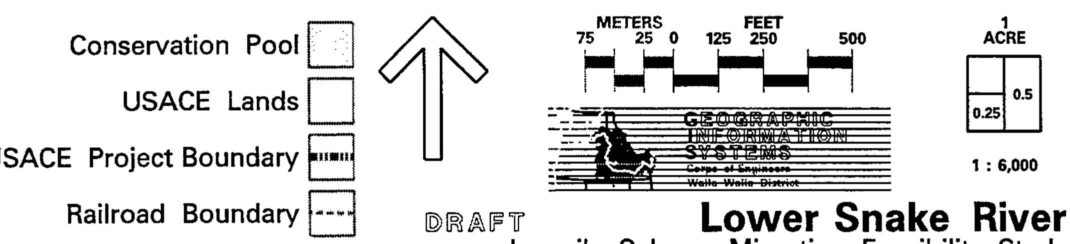
Figure 2-8. Looking South at Little Goose Facility

Little Goose has five major components (Figure 2-9). From the south (top bank) to north (lower bank), they are the navigation lock, fish passage facilities, powerhouse, spillway, and non-overflow embankment. The dam, located at the head of Lake Herbert G. West, is 2,655 feet long with an effective height of 98 feet. The normal operating range of Lake Bryan (the reservoir) extends from 633 feet to 638 feet msl. The powerhouse is 656 feet long and 243 feet wide, and houses six 135-MW generators. Next to the powerhouse is a 512-foot-long concrete spillway equipped with steel tainter gates. The spillway has eight spill bays. The tainter gates are each 50 feet wide by 60 feet high. A concrete-lined stilling basin extends 118 feet downstream from the spillway along the river bottom.

The navigation lock at Little Goose is a single-lift type, 668 feet long by 86 feet wide, with a 15-foot minimum depth and a maximum lift of 101 feet. Next to the navigation lock is the north dam embankment, which is a gravel fill structure with rock facing and an impervious core. Juvenile fish passage facilities at Little Goose consist of a bypass system and transportation facilities (see Table 2-2 and Sections 2.1.1, Adult Fish, and 2.1.2, Juvenile Fish). Adult fish passage facilities are composed of one fish ladder on the south shore, a powerhouse collection system, and an auxiliary water supply system.

There are 4,859.6 acres of project lands surrounding Lake Bryan. These project lands include both fee and easement lands. The majority of the Corps-managed lands are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development. Currently, two areas of approximately 150 acres are leased either to the state or local ports for recreation. There are seven developed recreation areas adjacent to





DRAFT

Lower Snake River
Juvenile Salmon Migration Feasibility Study

Figure 2–9.
SCHEMATIC OF LITTLE GOOSE FACILITY

GIS Analysts & Graphic Assembly: Applied Technology Team (CENWW-PM-PD-E)
g:\regional\reg\plates\lsr\lsrlgadv.dgn:GISFILE PLOTTED: 06 DEC 1999

1999

Lake Bryan. These include 6 boat ramps with 13 launch lanes, 1 marina, 3 day-use facilities, and 2 campgrounds with a total of approximately 88 individual campsites. There are 18 HMUs, totaling 3,019 acres, along the reservoir. Water pumped from the pool is used to irrigate two of these HMUs. Well water is used to irrigate one HMU. There are three port facilities on Lake Bryan (Almota, Central Ferry, and Garfield), all used for grain. The port at Central Ferry also services other commodities.

2.2.3 Lower Monumental

Lower Monumental is located on the Snake River at RM 41.6 near Magallon, Washington (Figure 2-10). The dam is named after a large rock with vertical basalt columns. This rock, named Ship Rock by Lewis and Clark, was later renamed Monumental Rock. The reservoir at Lower Monumental, named Lake Herbert G. West in 1978, extends 28.7 miles upstream to Little Goose. Lower Monumental was placed into service in 1969.

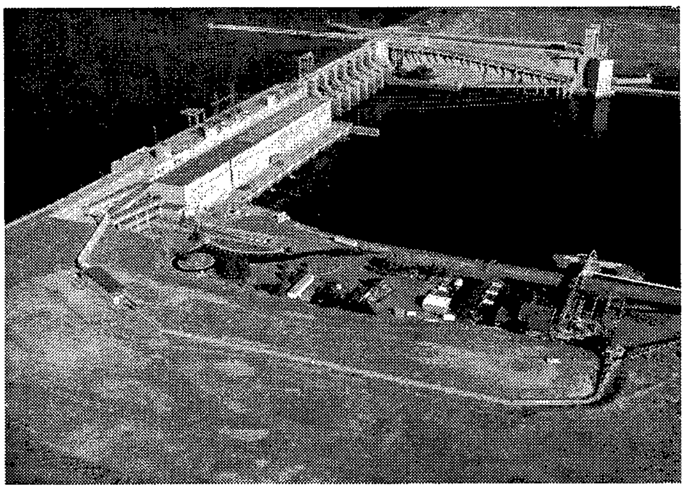
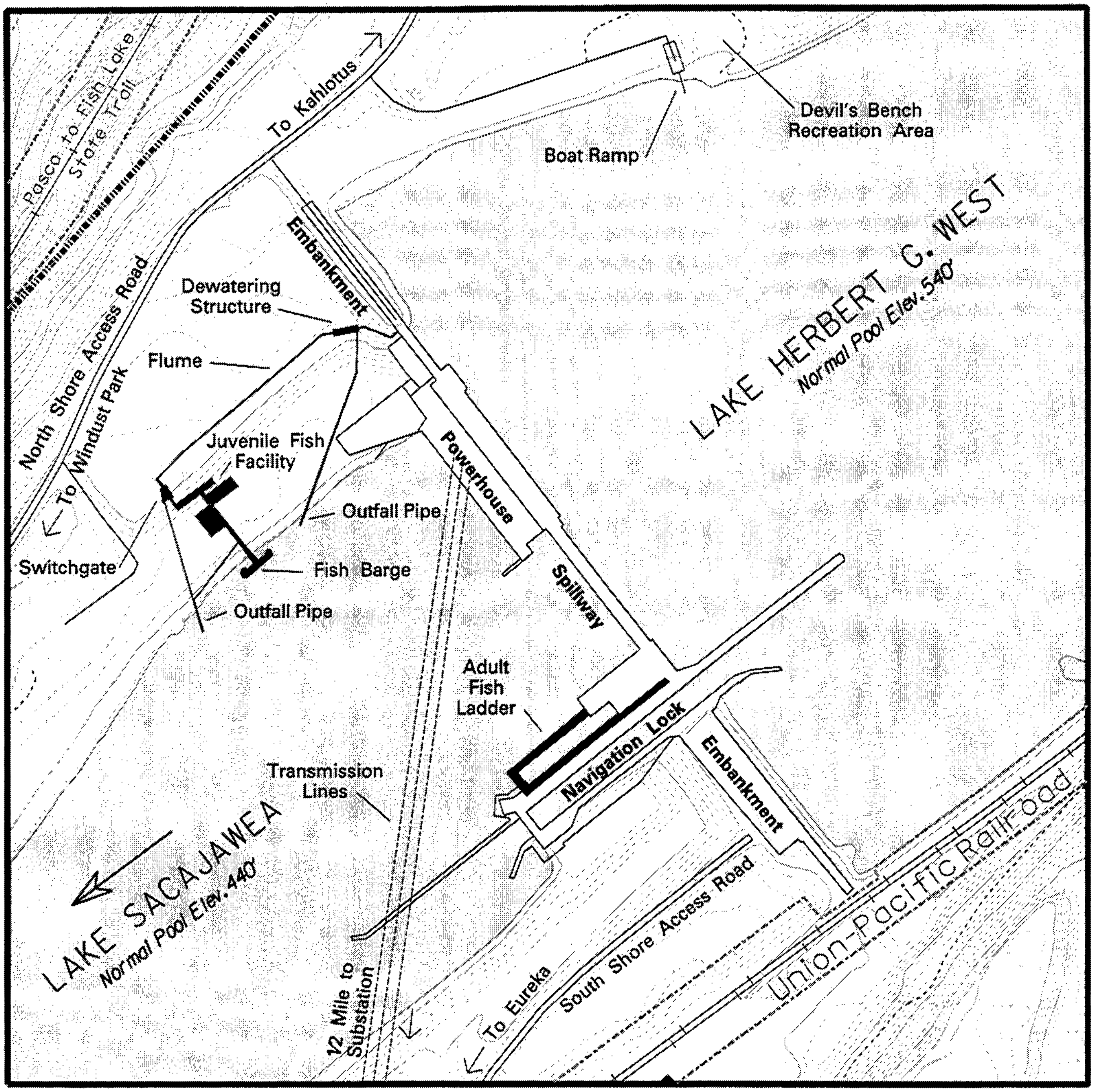


Figure 2-10. Looking South at Lower Monumental Facility

Lower Monumental has five major components (Figure 2-11). From the south (top bank) north (lower bank), they are the south non-overflow embankment, navigation lock, fish passage, and the north non-overflow embankment), spillway, powerhouse, and the north to north (lower bank), they are the south non-overflow embankment, navigation lock, fish passage facilities (also located between the powerhouse and the north non-overflow embankment), spillway, powerhouse, and the north non-overflow embankment. The dam, located at the head of Lake Sacajawea, is 3,791 feet long, with an effective height of 100 feet. The normal operating range of Lake Herbert G. West (the reservoir) is from 537 to 540 feet msl. The powerhouse is 656 feet long and houses six 135-MW generators. Next to the powerhouse is a 498-foot-long concrete spillway equipped with steel tainter gates. The spillway has eight spill bays, each 50 feet wide. The tainter gates are each 50 feet wide by 60 feet high. A concrete-lined stilling basin extends 180 feet downstream from the spillway on the river bottom. The navigation lock at Lower Monumental is a single-lift type, 666 feet long by 86 feet wide, with a 14-foot minimum operating depth and a maximum lift of 103 feet. Next to the navigation lock is the north dam embankment, which is 968 feet long.



Conservation Pool

USACE Lands

USACE Project Boundary

Railroad Boundary

Access Road

Service Road

10–Foot Contour Lines

METERS 75 25 0 FEET 125 250 500

1 ACRE 0.25 0.5

GEOGRAPHIC INFORMATION SYSTEMS Corps of Engineers Walla Walla District

1 : 6,000

DRAFT

Lower Snake River
Juvenile Salmon Migration Feasibility Study

Figure 2–11.
SCHEMATIC OF LOWER MONUMENTAL FACILITY

GIS Analysts & Graphic Assembly: Applied Technology Team (CEMWW-PM-PD-E)
g:\regional\reg\plates\lsr\lsrlmadv.dgn:GISFILE PLOTTED: 06 DEC 1999

1999

Juvenile fish passage facilities at Lower Monumental consist of a bypass system and transportation facilities (see Table 2-2 and Sections 2.1.1, Adult Fish, and 2.1.2, Juvenile Fish). Adult fish passage facilities are comprised of north and south shore fish ladders, a powerhouse collection system, and an auxiliary water supply system.

There are 9,143.6 acres of project lands surrounding Lake Herbert G. West. These project lands include both fee and easement lands. Port districts own land both on and adjacent to the project lands for industrial development. The majority of the Corps-managed lands, 7,024.0 acres, are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development. Approximately 1,177 acres are leased to the State of Washington for Lyons Ferry State Park.

There are six developed recreation areas adjacent to the Lake Herbert G. West. These include 4 boat ramps with 8 launch lanes, 1 marina, 9 day-use facilities, and 1 campground with approximately 50 individual campsites. There are 13 HMUs, totaling 4,381 acres, along the reservoir. Water pumped from the pool is used to irrigate two of these HMUs. Well water is used to irrigate one HMU. There is one port on the reservoir (Lyons Ferry). It is used for grain.

2.2.4 Ice Harbor

Ice Harbor is located on the Snake River at RM 9.7 near Levee, Washington (Figure 2-12). Major cities in the local vicinity include Kennewick and Pasco, which are located upstream of the confluence of the lower Snake and Columbia rivers, and Richland, which is located at the confluence of the Yakima and Columbia rivers. Ice Harbor is named after a mooring spot a few miles upstream of the Snake-Columbia confluence.

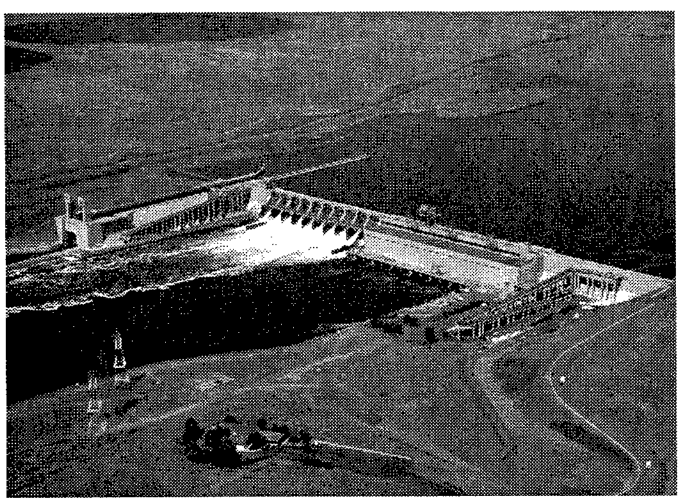
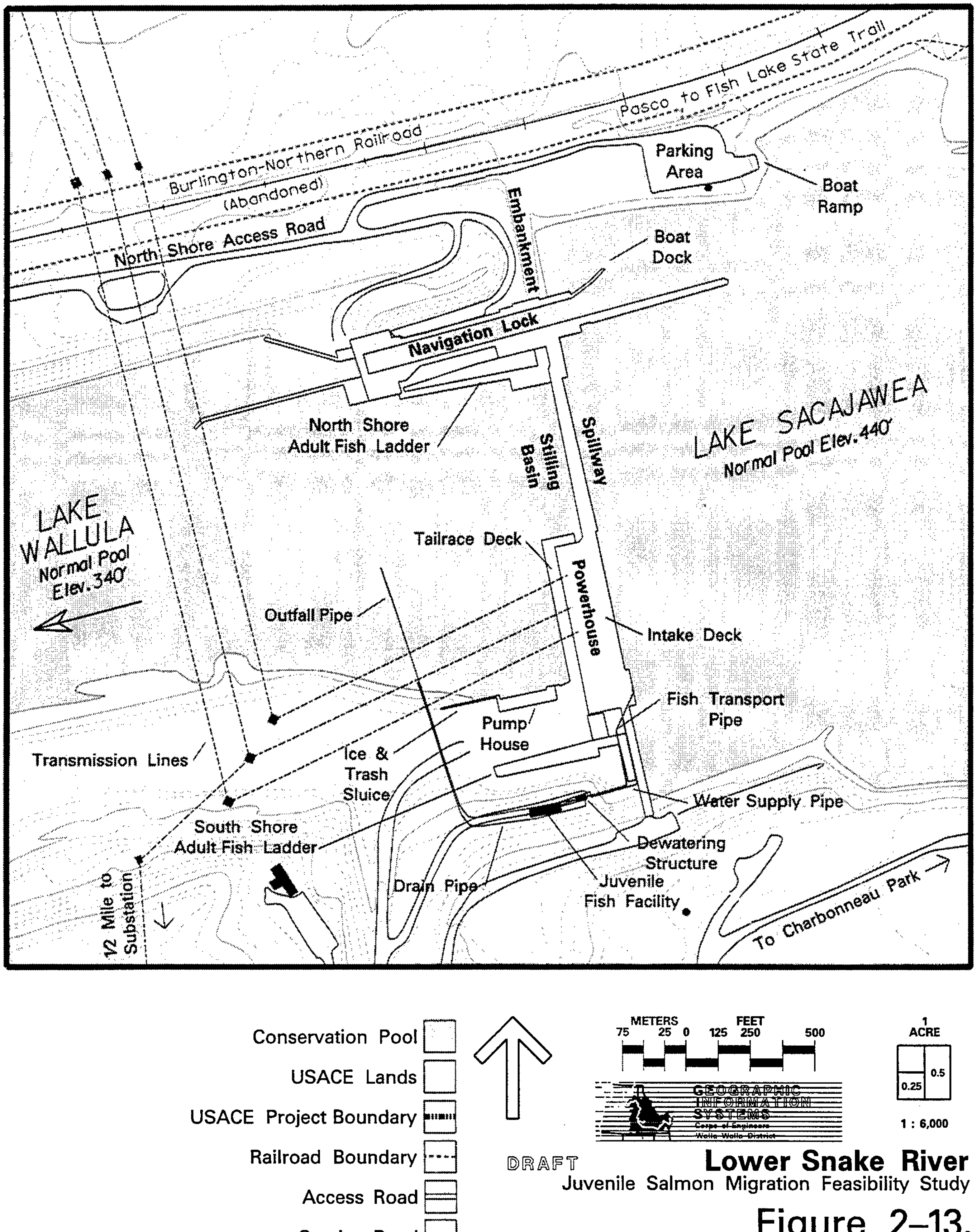


Figure 2-12. Looking Northeast at Ice Harbor Facility

The reservoir at Ice Harbor, known as Lake Sacajawea, extends 31.9 miles upstream to Lower Monumental. Ice Harbor was placed into service in 1961. Ice Harbor has five major components (Figure 2-13). From the south (right bank) to north (left bank), they are the fish passage facilities (also located between the spillway and the navigation lock) powerhouse, spillway, navigation lock, and non-overflow embankment. The dam is



DRAFT

Lower Snake River
Juvenile Salmon Migration Feasibility Study

Figure 2-13.
SCHEMATIC OF ICE HARBOR FACILITY

1999

GIS Analysis & Graphic Assembly: Applied Technology Team (CENWW-PM-PD-E)
g:\regional\reg\plates\lsr\lsrhlddv.dgn:GISFILE PLOTTED: 06 DEC 1999

2,822 feet long, with an effective height of 100 feet. The normal operating range of Lake Sacajawea extends from 437 to 440 feet msl. The powerhouse is 671 feet long and houses three 90,000-kilowatt (KW) and three 110-MW generators. Next to the powerhouse is a 590-foot-long concrete spillway equipped with steel tainter gates. The spillway has 10 spill bays, each 50 feet wide. The tainter gates are each 50 feet wide by 52.9 feet high. A concrete-lined stilling basin extends 168 feet downstream from the spillway along the river bottom.

The navigation lock at Ice Harbor is a single-lift type, 675 feet long by 86 feet wide, with a 15-foot minimum depth and a maximum lift of 105 feet. Next to the navigation lock is the north dam embankment, which is 624 feet long.

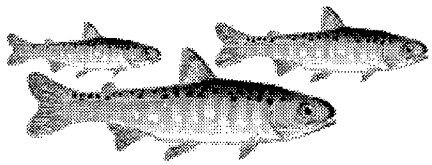
Juvenile fish passage facilities at Ice Harbor consist of a bypass system and juvenile transportation facilities. Adult fish passage facilities are made up of separate north and south shore facilities (see Table 2-2 and Sections 2.1.1, Adult Fish and 2.1.2, Juvenile Fish). The north shore facilities include a fish ladder, a small collection system, and an auxiliary water supply system. The south shore facilities are comprised of a fish ladder, a powerhouse collection system, and an auxiliary water supply system.

There are 4,037.7 acres of project lands surrounding Lake Sacajawea. These lands include both fee and easement lands. The majority of the Corps-managed lands, 3,517.3 acres, are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development.

There are seven developed recreation areas adjacent to the Lake Sacajawea. These include 6 boat ramps with 10 launch lanes, 1 marina, 2 moorage facilities, and 3 campgrounds with a total of approximately 125 individual campsites. There are 14 HMUs, totaling 2,032 acres, along the reservoir. Water pumped from the pool is used to irrigate 3 of these HMUs.

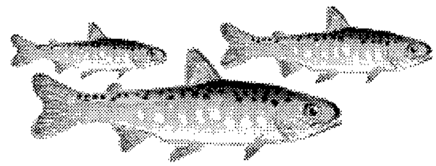
There are two ports on Lake Sacajawea (Windust and Sheffler). Both are used for grain.

Approximately 37,000 acres of non-Federal land are presently irrigated with water pumped from Lake Sacajawea. Between the 14 irrigation pumping stations at the reservoir, there are about 75 pumps. The irrigated lands grow a variety of crops, including cottonwood/poplar trees, potatoes, and corn.



Chapter 3

Plan Formulation



3. Plan Formulation

In response to NMFS' 1995 Biological Opinion and the results of the *Interim Status Report* (Corps, 1996a), the Corps continued evaluating various improvements to the Lower Snake River Project. These improvements are intended to improve the effectiveness of downstream migration by juvenile salmonids and upstream passage of adults. This section describes the four alternatives that are evaluated in detail (Sections 3.1 through 3.4). These alternatives include:

- Alternative 1—Existing Conditions
- Alternative 2—Maximum Transport of Juvenile Salmon
- Alternative 3—Major System Improvements
- Alternative 4—Dam Breaching.

This section also addresses actions that were considered, but were not evaluated in detail in this FR/EIS because they were either outside the scope of the FR/EIS (Section 3.5) or they were eliminated from further consideration for various reasons (Section 3.6). Further details on dam breaching alternatives and major system improvements are provided in Technical Appendix D, Natural River Drawdown

Engineering, and Technical Appendix E, Existing Systems and Major System Improvements Engineering, respectively.

3.1 Alternative 1—Existing Conditions

Alternative 1—Existing Conditions consists of continuing the operation of the fish passage facilities and project operations that were in place or under development at the time that this FR/EIS was initiated. They would continue to meet the authorized uses of the Lower Snake River Project (see Section 1.2, Purpose and Need). Figure 3-1 summarizes the activities that would continue with the existing operations (and activities for other alternatives). These operations are described in detail in Section 2.0, Affected Projects and Programs. Existing environmental conditions are described in Section 4.0, Affected Environment. This alternative is the base case or "no action" alternative considered in this National Environmental Policy Act (NEPA) process.

Project operations—including all ancillary facilities such as fish hatcheries and Habitat Management Units (HMUs) under the Comp Plan (see Section 2.1.8, Lower Snake River Fish and Wildlife Compensation Plan), recreation facilities, power generation, and irrigation—would remain the same, unless modified through future actions. For example, the captive broodstock program of the Comp Plan could be expanded to include all listed species, which could modify some or all hatchery operations from producing high numbers of juvenile salmon to fewer, but higher quality, juveniles that may have a higher survival rate.

Adult and juvenile fish passage facilities would continue to operate. Similarly, testing of surface bypass collectors (SBC) at Lower Granite would continue through 2001. Information gained from this testing can be used as applicable for other projects on the Columbia River System.

Existing operations include several other planned measures that would be used to increase fish passage survival. These include:

- **New Turbine Cams**—The cams that control the turbine blades and wicket gates may be modified to increase the hydraulic efficiency of the turbines. The increased hydraulic efficiency of the turbines would likely reduce fish mortality. The existing condition assumes the modified cams would be added to all turbines at all dams.
- **New Turbine Runners**—Studies are currently underway to develop turbine runners that reduce fish injury and associated mortality for those juvenile fish passing through the turbines. It is assumed that for the existing conditions, all turbines and generators would eventually require rehabilitation and, therefore, new turbine runners.
- **Upgrade Lower Granite Juvenile Fish Facilities**—Certain structural modifications and upgrades would be made to this facility to more effectively handle fish. Examples include upgrades to the raceways and distribution flume systems at the collection facility, upgrades to direct barge loading facilities, and modifications to existing structures.

	ALTERNATIVES			
	Alternative 1-Existing Conditions	Alternative 2-Maximum Transport of Juvenile Salmon	Alternative 3-Major System Improvements	Alternative 4-Dam Breaching
STRUCTURAL MODIFICATIONS				
Upgrade Juvenile Fish Facility (LGR)	√	√	√	
Additional Barges	√	√	√	
Juvenile Fish Separator Improvements	√	√	√	
(LMO/LGO/LGR)	√	√	√	
New Cylindrical Dewatering Screens	√	√	√	
New Trash Boom (LGO)	√	√	√	
End Bay Deflectors/Pier Extensions (LMO/LGO)	√			
Dams Breached				√
Extended Length Submerged Bar Screen				
ESBS Improvements (LGO/LGR)	√	√	√	
New ESBS (IH/LMO)			√	
Surface Bypass Collector w/ Dewatering System and Behavioral Guidance Structure				
Full Powerhouse (LGR)			√	
OPERATIONAL ELEMENTS				
Flow Augmentation				
1995/98 Biological Opinions	√	√	√	√
Spill				
1995/98 Biological Opinions	√			
Volunteer Spill at Ice Harbor Only		√	√	
No Volunteer Spill				
Transport				
1995/98 Biological Opinions	√			
Maximize Transportation/Limited In-River Migration		√	√	
No Transportation/Maximize In-River Migration				√
Navigation				
Current Configuration	√	√	√	
No Navigation				√
Powerhouse Operation				
1995/98 Biological Opinions	√	√	√	
Turbine Cam Optimization Evaluation	√	√	√	
No Power Production				√
Miscellaneous Major Maintenance	√	√	√	
Adult Fish Facilities	√	√	√	
Juvenile Fish Bypass /Collection System	√	√	√	
MISCELLANEOUS ELEMENTS				
Comp Plan Requirements				
Current Operation	√	√	√	
Hatchery Program to Include Captive Broodstock	√	√	√	√
Entire Operation Amended				√
Recreation Requirements				
Current Operation	√	√	√	
Amended Operation				√

√ Indicates that action would proceed

(empty box) Indicates no action planned

LGR = Lower Granite
LMO = Lower Monumental
LGO = Little Goose
IH = Ice Harbor

Figure 3-1. Lower Snake River Juvenile Salmon Migration Feasibility Study, Alternatives Matrix

wpros\1346\DEIS\12728t.xls 12/7/99

- **New Fish Barges**—Seven additional barges would be constructed to allow direct loading at fish collection facilities. Direct loading would reduce the amount of fish handling and associated stress. These would replace two barges scheduled for retirement and would provide additional capacity.
- **Adult Fish Attraction Modifications**—The adult fish attraction water at selected dams would be modified in order to ensure an adequate water supply for the fish ladders in the event of a pump failure.
- **Trash Boom at Little Goose**—A new trash boom would be constructed in winter 1999-2000 in the forebay of Little Goose to capture more debris before it can get into the juvenile fish facilities.
- **Modified Fish Separators**—To improve fish separation and to reduce fish stress, delay, and mortality at existing juvenile fish facilities, the existing fish separators would be modified. New separators would be installed at Little Goose and Lower Monumental, and would be included in an upgrade of the Lower Granite juvenile fish facility.
- **Cylindrical Dewatering Screens**—Cylindrical dewatering screens would be installed at Little Goose, Lower Monumental, and Ice Harbor, and included in an upgrade of the Lower Granite juvenile fish facility. These screens reduce the amount of water routed into the fish collection facilities. They are a more effective means (compared to stationary screens) for avoiding plugging of screens and for removing trash from the inflow. This screen design may be an improvement over existing stationary screen designs.
- **Spillway Flow Deflectors/Pier Extensions**—Additional spillway flow deflectors, modifications to existing spillway flow deflectors, and pier wall extensions would be added at Lower Granite, Little Goose, and Lower Monumental. These improvements are expected to further reduce dissolved gas concentrations. They would be similar to the designs for the recently installed deflections at Ice Harbor.
- **Improvements to the Extended Submerged Bar Screens (ESBSs)**—It is planned to modify the existing ESBSs at Lower Granite and Little Goose to improve their operability and longevity.

3.2 Alternative 2—Maximum Transport of Juvenile Salmon

All of the existing or planned structural configurations from the existing conditions would be included in this alternative (Figure 3-1). Project operations—including all ancillary facilities such as fish hatcheries and HMUs under the Comp Plan (see Section 2.1.8, Lower Snake River Fish and Wildlife Compensation Plan), recreation facilities, power generation, and irrigation—would remain the same, unless modified through future actions. However, this alternative assumes that the juvenile fishway systems would be operated to maximize fish transport and that voluntary spill would not be used to bypass fish through the spillways (except at Ice Harbor).

To accommodate maximum transport, measures would be used to maintain, upgrade, and significantly improve fish facilities (see Section 3.1, Alternative 1—Existing Conditions) that would focus on limiting in-river migration. For example, even though conditions for flow augmentation under the 1995 and 1998 Biological

Opinions would be met, in-river migration would be minimized by limiting spill, and fish collected in facilities would be transported downstream by trucks or barges rather than bypassed below the dams. Also, there would be no need to modify spillway flow deflectors or pier extensions with this alternative, since voluntary spill would be eliminated.

3.3 Alternative 3—Major System Improvements

This alternative would include most structural configurations found with the maximum transport alternative (Figure 3-1). Project operations—including all ancillary facilities such as fish hatcheries and HMUs under the Comp Plan (see Section 2.1.8, Lower Snake River Fish and Wildlife Compensation Plan), recreation facilities, power generation, and irrigation—would remain the same, unless modified through future actions. However, major system improvements that are focused on more effective diversion of juvenile fish away from the turbines would be implemented using SBCs (Figures 3-2a and 3-2b).

Under this alternative, the number of fish collected and delivered to the upgraded transportation facilities at each dam would be maximized. A full length powerhouse SBC would be provided at Lower Granite. This would be used in conjunction with existing ESBSs and a new behavioral guidance system (BGS). The BGS (Figure 3-2b) is a long and deep physical structure used to guide migrating juvenile fish to the SBC. Fish collected by both bypass structures would be combined and delivered to the transportation facilities, and either trucked or barged downstream. Implementation of the SBC system with transportation would involve a high volume dewatering system which results in directing juvenile fish from a large and dispersed volume of water to a smaller volume where they can be more readily collected. A variety of options under this alternative could be implemented, depending on results of ongoing or future tests of equipment, facilities, and approaches.

The combined SBC and ESBS systems would only be installed at Lower Granite because the majority of juvenile salmon coming down the Snake River originate above Lower Granite. Therefore, if the system at this facility is effective, there would be few migrating fish left in the river below Lower Granite and extensive collection systems at downstream locations would be less needed. Lower Granite and Little Goose currently have ESBSs installed in the turbine intakes. These would continue to be used, but would be modified to increase their operability and longevity. However, the intakes at Lower Monumental are currently outfitted with submerged traveling screens (STSs). These would be removed and replaced with ESBSs to increase the screen diversion efficiency, and further reduce the number of fish passing through the turbines.

At Ice Harbor, the turbine intakes are also currently outfitted with STSs. As at Lower Monumental, these would be removed and replaced with ESBSs to increase the diversion efficiency of the screening system. If the combination of the SBC and the ESBS systems function as anticipated at Lower Granite, construction of SBCs at the three lower dams may not appear to be justified. Fish do enter the lower Snake River from a series of tributaries, some very small and some sizeable, below Lower Granite.

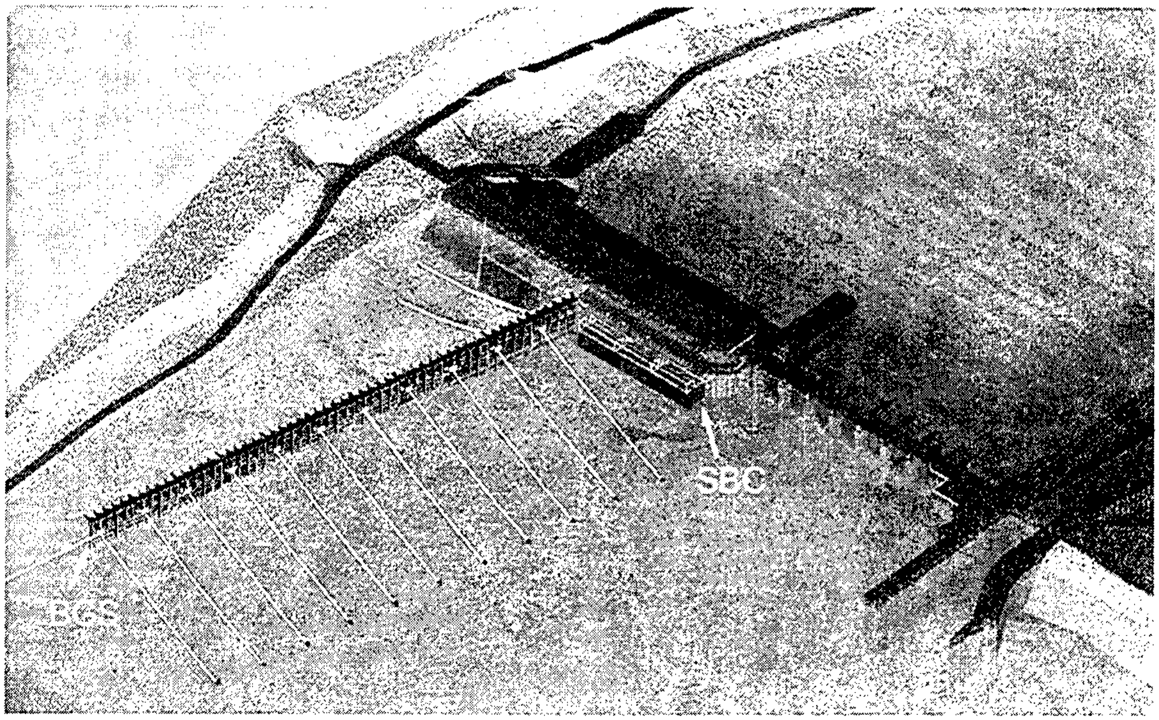


Figure 3-2a. Surface Bypass Collector Prototype System

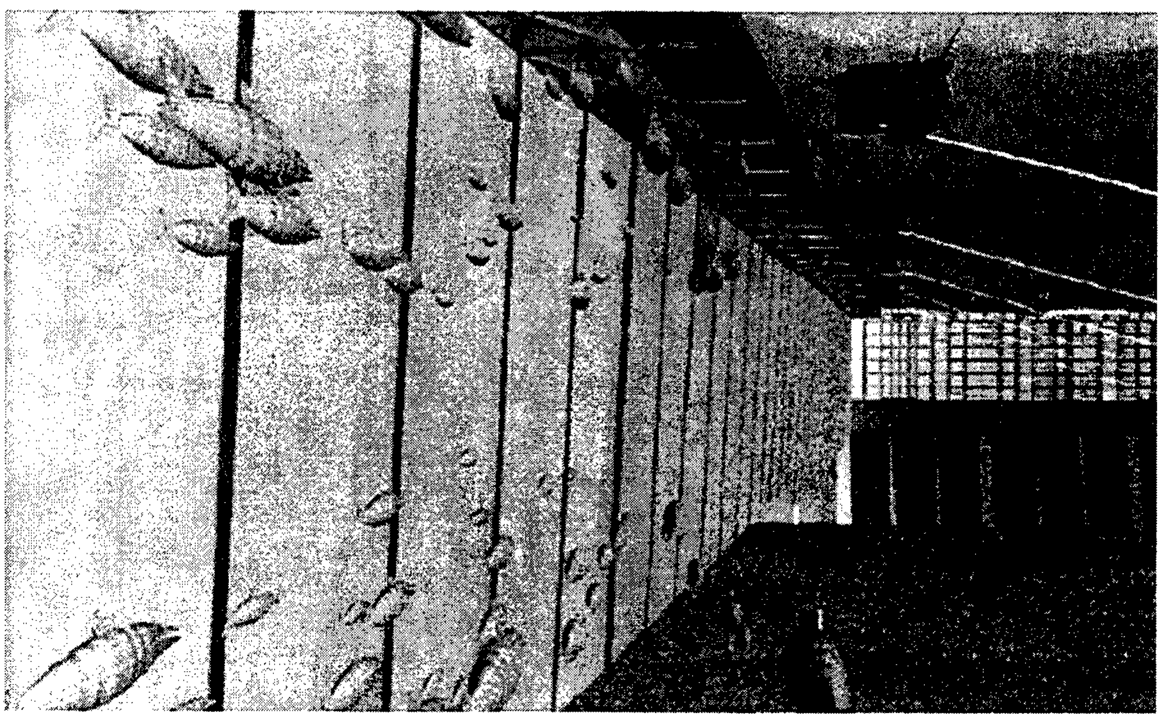


Figure 3-2b. Behavioral Guidance Structure Underwater View

Notable tributaries include Deadmen Creek, Meadow Creek, Tucannon River, and Palouse River. However, the numbers of fish entering from these tributaries are likely quite small compared to numbers entering Lower Granite Reservoir and encountering the dam. This approach is further justified by the fact that no fish enter the Snake River between Lower Monumental and Ice Harbor.

3.4 Alternative 4—Dam Breaching

The *Interim Status Report* (Corps, 1996a) considered three drawdown options: 1) seasonal, spillway crest; 2) seasonal, natural river drawdown; and 3) permanent, natural river drawdown. None of these drawdown options specifically incorporated a dam breaching scenario (see Section 1.2, Purpose and Need).

The dam breaching scenario differs from all other drawdown scenarios. Structural modifications are undertaken at the dams, allowing reservoirs to be drained, and resulting in a free-flowing river that would remain unimpounded. For example, with flows of 20,000 cubic feet per second (cfs), the total drawdown below normal maximum pool levels would be approximately 115 feet at Lower Granite, 114 feet at Little Goose, 108 feet at Lower Monumental, and 97 feet at Ice Harbor. Breaching of only one, two, or three dams was not considered in this FR/EIS because the removal of only one dam would eliminate major navigation in the lower Snake River and would curtail options for collecting and transporting juvenile fish. In addition, the 1995 Biological Opinion only addressed drawdown concepts for all lower Snake River reservoirs.

With dam breaching, the navigation locks would no longer be operational, and navigation for larger vessels would be curtailed. Similarly, recreation opportunities, operation and maintenance of hatcheries and HMUs, and other activities associated with the modification from a reservoir environment to an unimpounded river in the lower Snake River would entail important changes in these activities (see Sections 5.10.2, 5.12, and 5.5.2 for details on specific changes). No hydropower would be produced at the four dams under this alternative.

For dam breaching, the primary reason for leaving portions of the project in place is that it meets the operational criteria at the lowest practical cost. However, modifications to structures would be done in such a manner that the structures could be restored to operating conditions with later modifications (Figure 3-3). With this alternative, reservoirs behind the four lower Snake River dams would be eliminated, which would result in a 140-mile free-flowing river. This requires the protection of structures from natural river flows, and the decommissioning of equipment and structures. Secondly, construction operations would be phased so that power production, navigation, and fish migration could continue until the last possible period.

Dam breaching would involve removal of the earthen embankment section and abutment at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor. Once the embankment is removed, the river would flow around the remaining structures (powerhouses, spillways, and navigation locks). Levees would be used to "shape" the river into a channel around these structures. Long-term maintenance or preservation of these powerhouses, spillways, and navigation locks would be minimal.

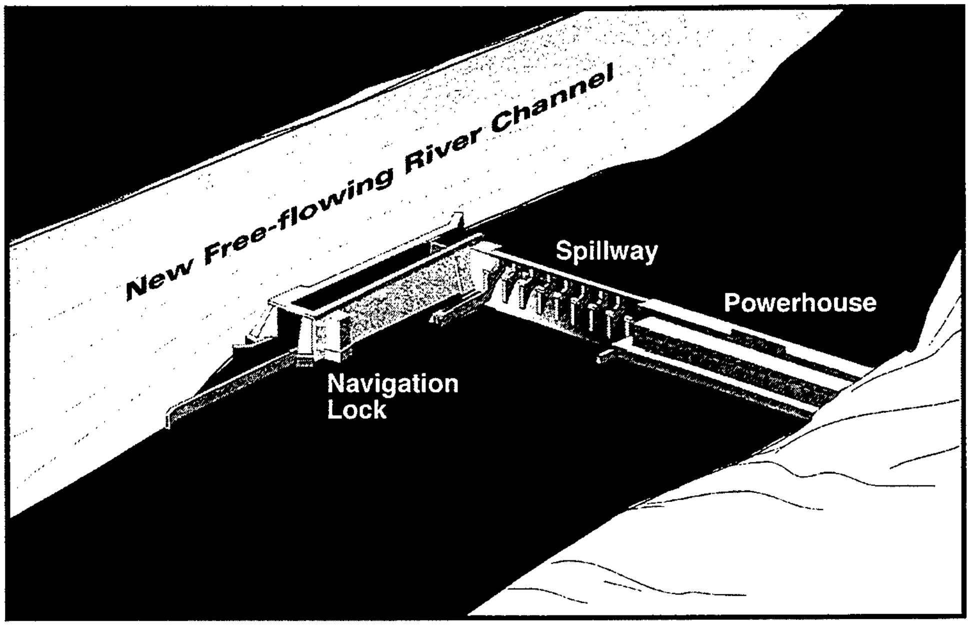


Figure 3-3. Dam Breaching

The following sections describe key aspects of dam breaching.

3.4.1 Reservoir Drawdown

The powerhouses and spillways would be used to lower upstream pool levels from full pools to near existing spillway crest elevations. Below spillway crest, the current powerhouses and existing spillways would become inoperable. Additionally, based on a drawdown rate of 2 feet per day, current facilities to pass juvenile and adult fish would be inoperable within a few days to two weeks of initiating the drawdown process.

Since none of the four lower Snake River dams were constructed with a low-level outlet, reservoir drawdown below spillway crest is not possible without some major structural modifications. Several options were considered to evacuate the reservoirs below spillway crest, including mining through the concrete of the spillway bays or the powerhouse, excavating through the embankment section, and modifying the navigation lock to discharge low-level flows. The selected option is to modify the 6 units so that water can be discharged through the units at varying reservoir levels.

It is necessary to provide a discharge capacity of 60,000 cfs. The minimum base flow for the Snake River during late fall and winter is 20,000 cfs. It is estimated that each powerhouse unit (1 of 6) must pass up to 15,000 cfs during various reservoir stages. Since each powerhouse bay is designed so that upstream and downstream bulkheads can be installed to stop flow, construction could proceed without the construction of independent cofferdams. Construction could proceed on some activities well in advance of the drawdown operation. However, early preparations will need to balance power generation, fish mitigation, and control of dissolved gas levels.

Although the construction of outlets through the powerhouse would allow drawdown of the majority of the reservoir, some ponding would still exist behind the earthen embankments. After draining as much water as possible through the new outlets, a

section of the embankments would be removed to allow the river to run through the channel.

Reservoir drafting would be controlled. For example, at Lower Granite, drafting would be limited to 2 feet per day, requiring 58 days to draft 115 feet below full pool. The total reservoir storage, in the four reservoirs, that would be evacuated during drawdown would be about 1.67 million acre-feet (MAF).

3.4.2 Required Modifications

A number of structural modifications to the features of each dam would be necessary for a permanent drawdown. Some embankment would be removed and replaced with a channel to allow free flow of the river. Some channelization of the river in the dam reach would be necessary to create hydraulic conditions that allow upstream fish migration. In addition, facilities for passing adult fish upstream and during construction activities, as well as during the time when the reservoir is being lowered will be needed. Criteria, assumptions, and key considerations for upstream fish passage during construction activities and for permanent drawdown were established for the feasibility evaluation. Construction activities will be orchestrated in a manner to ensure, so far as possible, that upstream passage of adult fish is not adversely affected. For example, it was assumed that channel velocities below 5 feet per second (ft/s) require no supplemental adult fish upstream passage facilities. Channel velocities above 5 ft/s require features in the river to produce rest areas. The higher the velocity, the more numerous and frequent the rest areas. It was also assumed that the maximum flow against which adult fish are assumed to swim upstream is 170,000 cfs, which is approximately the 2-year flood. Specific options and facilities for adult fish passage during construction are described in Section 3 of Technical Appendix D, Natural River Drawdown Engineering.

Juvenile fish would be allowed to pass downstream through the open channel that would be present after dam breaching. Collection and transport facilities for juveniles would no longer be operated following dam breaching. Construction will occur August through December, a period where downstream passage of juveniles does not occur, except for subyearling fall chinook salmon smolts that pass through October, depending upon annual flow and subsequent water temperature resulting from augmentation operations upriver (see Section 4.5.1, Anadromous Fish).

Additional criteria, assumptions, and key considerations for dam breaching included in the feasibility studies were:

No Catastrophic Drawdown

The evacuation of the reservoirs would be done at a maximum fixed rate of 2 feet per day. This rate would avoid slope failures in the reservoirs, which could put highways and railroads out of service.

Minimal Cost

When considering various options for implementing drawdown, the lowest cost option was the primary consideration. The goal of the Feasibility Study was to identify the major activities necessary to implement a four-reservoir drawdown and to document a feasible, reasonable method to accomplish those activities.

Mitigation Measures

Numerous construction activities and post-construction mitigation measures were assumed for implementation of dam breaching and modification of existing structures in the reservoirs. Direct measures are those activities necessary to evacuate each reservoir, remove a portion of the dam structure, and establish a river channel at each dam site. An example would include maintaining conditions for upstream passage of adult fish. In addition to these activities, modifications and repairs to transportation facilities adjacent to and across the river (e.g., bridge supports will need additional protection from potential scour) will be needed. Existing access to the river for cattle watering and protection of cultural resources will need to be addressed.

Other discretionary mitigation measures were also considered because they are authorized under current and anticipated project authorization but are not necessarily identified by public law. Examples include modifications to current wildlife mitigation lands, modifications to an operating fish hatchery, and measures to provide river access and appropriate recreation facilities. These are evaluated in greater detail in the respective sections of this FR/EIS.

The process of decommissioning the project requires a number of tasks. Key modifications are discussed in detail in the following sections.

3.4.2.1 Bulkheads

To use the turbine units as low-level outlets, some modification to the intake gates would be required. Upon completion of unit modifications, discharge through the turbine passages would be initiated by raising the intake gate, or by some coordinated operation of the turbine wicket gates and draft tube bulkheads. Neither gate was designed to regulate flow, so modification or replacement would be necessary so the gates would regulate discharge. Modifications may include gate strengthening, added operators, and new rollers and seals. Such modifications would apply to all gates. Further modifications may be necessary to the draft tube bulkheads.

3.4.2.2 Turbines/Generators

Modifications to turbines and associated equipment would be necessary to allow the use of the turbine and passages to function as outlets. Modifications would need to be completed well in advance of drawdown. However, some turbine capacity must be maintained during the previous spill season in order to aid in controlling the dissolved gas levels in the river. Excessive spillway use raises dissolved gas levels to unacceptable levels. Modifications must be scheduled so that turbine use is maximized and spillway use is limited to acceptable timeframes.

The operating turbine and generator serve to dissipate the energy of a high head and allow the passage of a significant volume of water. In order to make the turbines operate at lower heads than the current operating head, numerous modifications must be made. A detailed report on the Turbine Passage Modification Plan is provided in Appendix D, Natural River Drawdown Engineering. In summary, these modifications are as follows:

- **Addition of Performance Instrumentation**—Additional instrumentation is necessary to monitor conditions of the turbine during out-of-the-ordinary

operations. The instrumentation identifies developing conditions that may lead to a failure of the system and may prevent the necessary discharge of water. Early warning provided by instrumentation allows operators to react and implement contingency plans.

- **Emergency Closure Devices**—Existing emergency closure devices should be in operating condition. The use of these gates is only in the event that conditions develop that could cause failure of the water outlet process and the purpose is to isolate that turbine passage. Currently, the intake gates at each project are either raised (with the hydraulic operators disconnected) or removed for improved fish passage purposes. During a reservoir drawdown, the fish screens would be removed. The intake gates should be connected to the hydraulic operators and stored in the normal position, ready for emergency use.
- **Cooling Water System**—Additional cooling water for turbines and generators would be required to supplement the existing gravity-fed system as the head drops.
- **Trash Rack Modifications**—Investigation is necessary to assure that the trashrack structures are adequate for debris loads over the range of head pressures to which they will be subject. Some strengthening has been assumed to be necessary for drawdown conditions. A significant effort will be required to keep the trash racks clear of debris during drawdown.
- **Draft Tube Bulkheads**—When more than one dam is drawn down at once, the tailwater of the upstream project will drop significantly. This drop in tailwater will cause serious cavitation problems for the turbines. Approaches for addressing these problems are provided in Technical Appendix D, Natural River Drawdown Engineering. Each dam only has one set of draft tube bulkheads, so additional bulkheads for the remaining five units would need to be purchased.
- **Turbine Blade Removal**—Up to three turbines at each project will require removal of the turbine blades to operate as bladeless runners. This will allow maximum discharge of water through the turbine passages at low heads. Removal is expected to be done several months in advance of drawdown by cutting the blades and removing them through the intake slot or out through the draft tube.
- **Operation**—Operation below the speed no load (SNL) condition is possible, but would require direct manual operation. It is not recommended without more critical evaluation. The increased risks and uncertainties of operating below SNL make this a potentially more dangerous operation.
- **Contingency Plans**—If equipment fails to operate as expected during the reservoir evacuation, contingency plans must be in place in order to continue the drawdown process and complete the embankment breach. Typical contingent operations might be operating turbine units manually at or below SNL status, breaching the embankment cofferdams at higher heads, and/or using a modified intake gate for regulated flow through the turbine passages.

3.4.2.3 Channel Preparation

Some operations related to channel excavation could be completed in advance of embankment excavation. The processing and stockpiling of riprap could also be done in advance. While some riprap could be salvaged for the embankment shells, additional riprap would be needed for protection against higher velocity and wider range of river flows. Riprap protection would be necessary adjacent to the navigation locks, adjacent to the spillway structures, and for the new levees.

3.4.2.4 Embankment Removal

Embankment removal would be expected to require a three-stage operation. The reservoir would be drawn down to spillway crest, while concurrent excavation of the upper embankment would be performed. Further drawdown would be done using the modified powerhouse units. Concurrent excavation of the embankment would continue at an accelerated rate. It may be that the powerhouse outlet configuration results in some reservoir impoundment when at its lowest level. Depending on the reservoir elevation, a controlled breach of the embankment may be necessary to provide final drawdown.

3.4.2.5 River Channelization

Channel channelization is expected to be relatively minimal. Final channel shaping would be done by dragline from the shore. Channelization would be necessary in the reservoir to capture the river, and divert it around the powerhouse and spillway structures. Channelization in the form of new levee structures would extend upstream some distance. Without these measures, areas may pond water, threatening water quality and creating fish migration difficulties.

3.4.2.6 Changes to Other Facilities

Numerous modifications would be necessary to ancillary structures (see Technical Appendix D, Natural River Drawdown Engineering, for details). These modifications would include:

- Bridge pier protection
- Railroad and highway embankment protection
- Protection of drainage culverts and pipe outfalls along each reservoir
- Railroad and roadway damage repair
- Modifications to water supply, adult fish ladder, and operations at the Lyons Ferry fish hatchery
- Modifications to HMUs
- Reservoir revegetation
- Modifications to cattle watering facilities
- Modifications for recreation access
- Cultural resources protection
- Once breaching begins, the dams would no longer produce power. Provisions to modify station service power feeds would be necessary to draw power from

other sources. Independent power systems may be necessary if other sources are unavailable (see Section 5.9, Electric Power)

- The relocation of roads, railroads, visitor facilities, and other facilities would be required to construct the new channels and bypass structures and to accommodate drawdown
- Flow augmentation would continue under the 1995 and 1998 Biological Opinion levels and the Comp Plan would be amended.

3.4.3 Lower Snake River Compensation Plan

The Comp Plan (see Section 2.1.8, Lower Snake River Fish and Wildlife Compensation Plan) was authorized to mitigate for fish and wildlife losses caused by the construction and operation of the four lower Snake River dams. Breaching of the dams would result in cessation of operations and return of the river to free flowing or unimpounded conditions in this reach. Therefore, the conditions that resulted in the need for the Comp Plan and its mitigation requirements would no longer exist. Therefore, the Comp Plan would continue, but would need to be amended.

Specific measures such as operation of existing fish hatcheries, wildlife habitat management units, and access would be discontinued or modified, likely over a transition period that would allow post-breaching conditions to stabilize. For example, operation and maintenance of HMUs and fish hatcheries may be discontinued whereas the operations of some remaining hatcheries would be modified to captive broodstock facilities that would be used to rebuild fish runs. The Lyons Ferry Hatchery may need to be maintained because the fall chinook salmon in this hatchery are included in the Snake River fall chinook evolutionarily significant unit (ESU). It is also likely that any new measures needed to mitigate the effects of breaching on fish and wildlife would have to be negotiated.

3.4.4 Implementation Schedule

Assuming that funds and resources are available when required, it is estimated that, from the date authority is granted and funds are appropriated, it would take about 9 years to fully implement Alternative 4—Dam Breaching. In addition, if more study or research identifies any unforeseen technical problems, additional time may be required to obtain acceptable solutions.

Dam breaching activities would take at least 2 full years to complete after an estimated 5-year period necessary for preparation of a detailed design report and assessment of contracts.

3.5 Other Potential Actions Outside the Scope of the FR/EIS

The purpose of this FR/EIS is to evaluate measures that may increase the survival of juvenile anadromous fish as they migrate past the four lower Snake River dams. Numerous other studies by the Corps, other Federal agencies, states, and tribes are also being conducted in the Snake River System and elsewhere in the Columbia River Basin to address salmonid species that are either at risk or listed under the Endangered Species Act (ESA). This FR/EIS addresses, in detail, alternatives that could be implemented at the four lower Snake River dams; it does not directly

address all other actions being considered in the Columbia River System (which are being addressed in other forums—see Section 1.4.5) to conserve and restore ESA-listed salmon runs. However, it does consider these other actions as part of the cumulative impacts analysis.

Additional actions that are outside the scope of this FR/EIS include:

- **Natural River Drawdown of Four Lower Snake River Reservoirs along with Drawdown of John Day Reservoir (includes existing 1995 and 1998 Biological Opinion flow augmentation in the mainstem Columbia River and the Snake River—this action was evaluated by PATH as Alternative B-1)**

  Senate Energy and Water Development Appropriation Bill No. 1998 authorized a study of the biological, social, and economic impacts of a drawdown of John Day Reservoir. The authorization is limited only to study of the drawdown of John Day Reservoir to spillway crest and to natural river level. The study would involve two phases:

  - Phase I is a preliminary evaluation of the potential impacts, including social and economic, of the four alternatives (drawdown to spillway crest and drawdown to natural river level, each with and without flood control).
  - Phase II is a multi-year feasibility-level study culminating in completion of an FR/EIS similar in scope to this document.

  The draft John Day Dam Drawdown Phase I report will recommend whether study of drawdowns of the John Day Reservoir to improve salmon and steelhead passage is warranted. The draft report is scheduled for release in mid-January 2000.

  Other measures are also being considered at John Day to improve the effectiveness of juvenile salmon migration. These measures include additional transportation, flow deflectors, collection facilities, and spill modifications. All of these measures are in the feasibility testing phase are under study or have been proposed. Therefore, they are not addressed in detail in this FR/EIS. They are, however, addressed in the cumulative effects. The actions at John Day and other lower Columbia River dams will be specifically addressed in detail in other NEPA documents. However, the timing of release of the John Day reconnaissance report will be too late for consideration in this FR/EIS.

- **Natural River Drawdown of Four Lower Snake River Reservoirs and John Day Reservoir (includes existing 1995 and 1998 Biological Opinion flow augmentation in the mainstem Columbia River, but with No Existing Flow Augmentation Measures in the Snake River (this action was not evaluated by PATH)**

  This action was not evaluated in detail for the same reasons that the previous action was not evaluated in detail.

3.6 Alternative Actions Eliminated from Further Consideration

A wide variety of other actions and options were identified, examined, and discussed in the preliminary analyses for the Feasibility Study (Corps, 1996a). These were eliminated from detailed evaluation and analysis for either one of several reasons including: 1) not meeting the purpose and need of this FR/EIS; 2) the probability of success of implementation of the action was considered low or unlikely, or 3) the action would be addressed in other forums or through other NEPA analyses. The general descriptions of the actions eliminated from detailed analysis are:

- **In-river Migration Option (no transportation, no drawdown, SBCs at all dams, and flow augmentation under the 1995 Biological Opinion) Plus an Additional One Million Acre Feet (1.0 MAF) Flow Augmentation (this action was evaluated by PATH as Alternative A-6)**

  With this action, spill would be maximized to the extent possible to bypass additional fish over the spillways. There would be no transportation of juvenile fish and in-river migration would be maximized. Augmentation flows would be increased by an additional 1.0 MAF.

  Juvenile fish would be passed directly downstream to the tailrace. To maximize diversion away from the turbines, ESBS intake diversion systems would be used in conjunction with the SBCs at all four dams to divert fish which might pass under the SBC and into the turbine intakes. Lower Granite and Little Goose already have ESBS systems, and these would continue to be used in conjunction with the new SBCs. The STS systems at Lower Monumental and Ice Harbor would be removed and replaced with new ESBS systems.

  The Corps has an interest in flow augmentation from upstream sources and how it would affect operations and juvenile fish passage in the lower Snake River. As a result, the Corps asked BOR for assistance in developing further information on flow augmentation, particularly regarding the feasibility and potential impacts of providing the 1.0 MAF additional flow augmentation. The current findings of BOR's studies are presented in the *Snake River Flow Augmentation Impact Analysis Appendix* (BOR, 1999). The report concludes additional flow augmentation would involve high costs and multiple implementation issues.

  Although the studies by BOR could lead to potential actions for improving juvenile salmon fish migration in the lower Snake River, the studies have not been conducted at the same level as this FR/EIS. BOR could not provide an impact analysis in comparative detail to this FR/EIS because of the uncertainty as to where in the Snake River tributaries and subbasins the 1.0 MAF would actually be acquired. Therefore, because of the high costs required for implementation, multiple implementation issues, and the uncertainty of availability of the 1.0 MAF, this action is not considered in detail in this FR/EIS, but is considered in the assessment of cumulative impacts.

  Additionally, PATH did a preliminary screening analysis of this alternative, designated as Alternative A-6, which found with "most realistic" assumptions that it performed at only 80 to 100 percent of the survival and recovery criteria

that PATH Alternative A-2 did. Therefore, it was unlikely this alternative would perform any better than alternatives considered fully and was not included for detailed assessment.

- **Maximized Transport at the Four Lower Snake River Facilities Without Voluntary Spill (with SBC development at all four lower Snake River dams—this action was not specifically evaluated by PATH, but is similar to A-2')**

  Under this alternative, the number of fish collected and delivered to the existing or upgraded transportation facilities located at each project would be maximized. Full length powerhouse SBCs would be provided at Lower Granite, Little Goose, and Lower Monumental. These would be used in conjunction with ESBSs located in the turbine intakes. Fish collected by both bypass structures would be combined and delivered to the transportation facilities, and either trucked or barged downstream.

  The upper two dams (Lower Granite and Little Goose) currently have ESBSs installed in the turbine intakes. These would continue to be used. However, the intakes at Lower Monumental are currently outfitted with STSs. These would be removed and replaced with ESBSs to increase the screen diversion efficiency, and further reduce the number of fish passing through the turbines.

  At Ice Harbor, the turbine intakes are also currently outfitted with STSs. As at Lower Monumental, these would be removed and replaced with ESBSs to increase the diversion efficiency of the screening system. However, no SBCs would be installed at Ice Harbor. If the combination of the SBC and the ESBS systems function as anticipated at Lower Granite (the major system improvements alternative), there should be very few migrating fish left in the river at the lower three dams (see Section 3.3, Alternative 3—Major System Improvements). This approach is further justified by the fact that no fish enter the Snake River between Lower Monumental and Ice Harbor. Therefore, construction of SBCs at all dams would not appear to be justified, and this alternative was eliminated from further consideration.

- **Adaptive Migration Strategy Without Voluntary Spill (this action was not evaluated by PATH)**

  This action assumes that the juvenile fishway systems would be operated in a manner that balances the passage of fish between in-river and transport fish passage methods. This would include the same fish passage strategy as described for the existing conditions alternative. However, voluntary spill would not be used to bypass additional fish over the spillways. Instead, options under the adaptive migration strategy would be used to spread-the-risk between transportation and in-river fish passage (via bypass/collection facilities). It should be noted that another form of adaptive migration strategy could emerge at any time in the study process and may become a reasonable alternative.

  Under this version of adaptive migration strategy there would be a flexible and adaptive approach for alternating between transportation and in-river fish passage. Facilities would not be operated the same as under existing conditions. For example, the adaptive migration strategy could exclude modified deflectors. In addition, at Lower Granite and Lower Monumental,

partial powerhouse length SBC systems would be constructed at turbine units 5 and 6. These two-unit SBC channels would have two side-by-side entrances. One entrance would pass the juvenile fish through a dewatering section so that they could be delivered into the existing juvenile bypass channel, and ultimately to the transportation facilities. The other entrance would not contain dewatering screens and would pass the fish directly to the tailrace through modified spill flow. To guide fish away from units 1 through 4, a BGS would be constructed in the forebay.

ESBS intake diversion systems would be used in conjunction with the two-unit SBC channels. At Lower Granite, the existing ESBS would be used, whereas at Lower Monumental, there would need to be new ESBSs. The ESBS would be located in turbine intakes at all six units, to offer a bypass for those fish which may pass under the BGS.

At Little Goose, a full length powerhouse SBC channel, without dewatering, would collect and pass fish directly to the tailrace. In addition, the existing ESBS intake diversion systems would also be used to pass fish.

At Ice Harbor, a spillway SBC would be constructed at spillbay 1, the spillway closest to the powerhouse. A BGS would be included in the forebay to direct fish toward the modified spillbay and away from the powerhouse.

The evaluation of this action needs further consideration of future testing (i.e., in the years 2000 and 2001) of the SBC at Lower Granite before the need for additional SBCs could be determined. Therefore, this action might be considered in the future, but is not considered further in this FR/EIS because testing has not been completed.

- **Natural River Drawdown of Four Lower Snake River Reservoirs Under Existing Flow Augmentation in Columbia River, but no Augmentation in the Snake River (this action was not evaluated by PATH)**

  This alternative was eliminated from detailed analysis because it is not consistent with the flow augmentation measures called for in the 1995 and 1998 Biological Opinions.

- **In-river Migration and No Augmentation Flow**

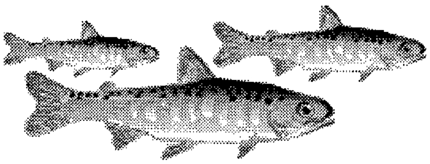
  This alternative was eliminated from detailed analysis because it was not recommended in the 1995 and 1998 Biological Opinions.

  PATH performed a preliminary screening analysis alternative (designated as Alternative A-6') with very similar characteristics to this alternative, but with the inclusion of SBCs at all Snake River dams to bypass fish. Even with the addition of SBC, which should enhance dam passage survival relative to current bypass systems, the PATH preliminary analysis found that this alternative performed worse than PATH Alternative A-2 relative to the NMFS survival and recovery criteria. Therefore, considering its poor performance and NMFS' lack of recommendation in its 1995 and 1998 Biological Opinions to study this alternative, this alternative was not carried to full alternative analysis.

- **Dam Removal (for PATH analysis, this action is equivalent to A-3)**

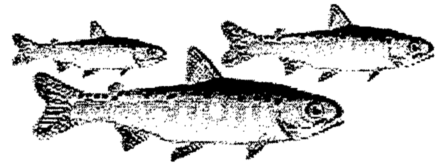
  Dam removal would include the same actions as described for dam breaching, but would also include removal of all structures (e.g., spillways, powerhouses,

navigation locks) at each facility. In addition, long-term maintenance of site structures or preservation of equipment would be eliminated. This alternative was not considered in detail because dam breaching would achieve the same results at a lower cost. In addition, the option of reestablishing the function of the dams in the future would be eliminated. Dam removal as an alternative would result in no increase in fish survival or recovery compared to the dam breaching without removal. Therefore, this alternative was eliminated from further consideration.



Chapter 4

Affected Environment



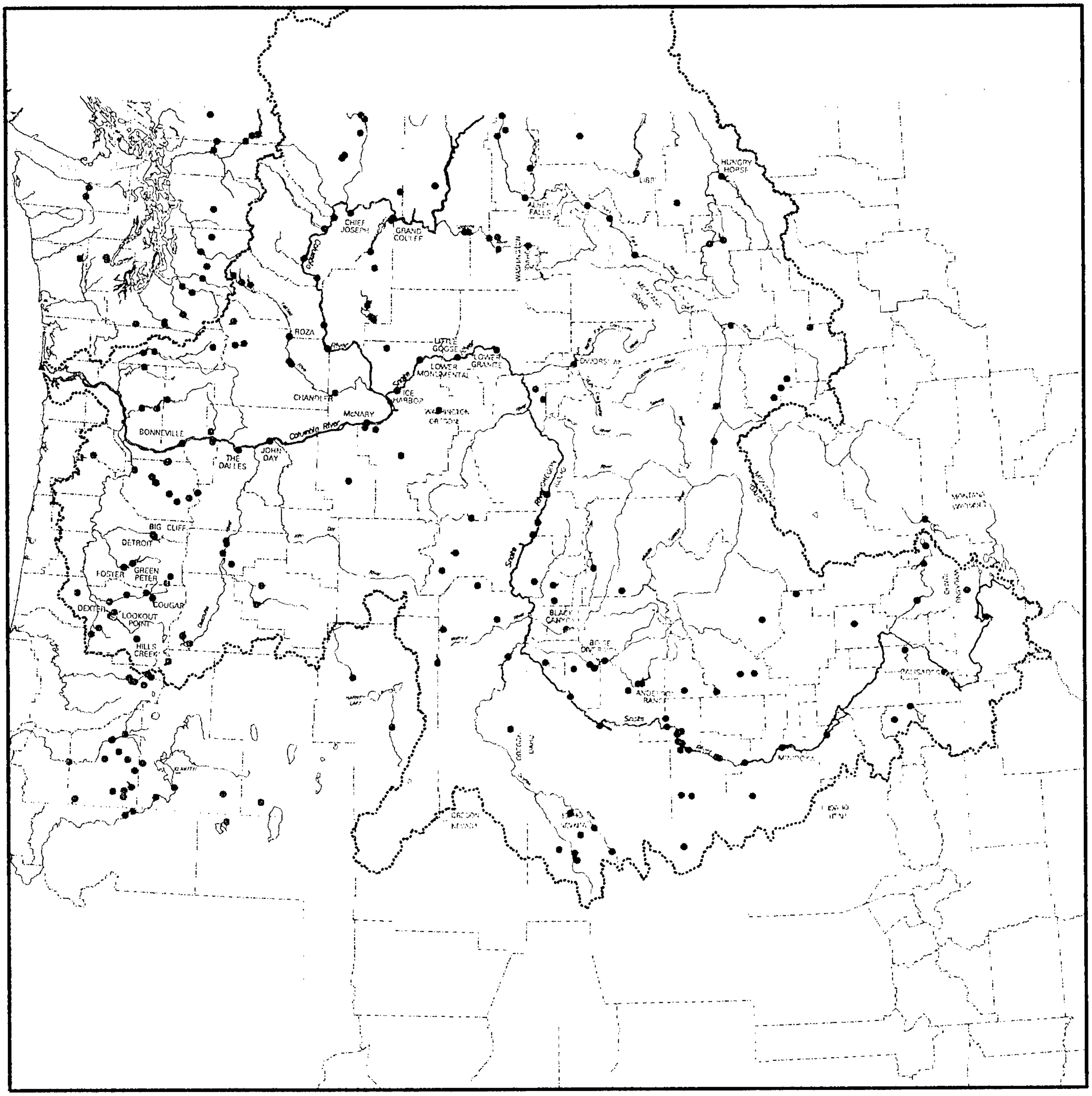
4.1 General Setting

4.1.1 Physical Environment

The Snake River is the principal tributary of the Columbia River. Originating in northwestern Wyoming, it winds its way 1,078 miles to its confluence with the Columbia River near Pasco, Washington. Major tributaries to the Snake River include the Salmon, Clearwater, Boise, Owyhee, Grande Ronde, Palouse, and Tucannon rivers. The Snake River originates in Yellowstone National Park. From there it flows south into Idaho and west across the broad Snake River Plain of southern Idaho to the Oregon-Idaho border. Here it turns north, forming part of the boundary between Idaho, Oregon, and Washington and flowing through Hells Canyon, a mile-deep canyon cut through the Seven Devils Mountain Range. Near Lewiston, Idaho, the Snake River is joined by the Clearwater River and turns west to join the Columbia River near Pasco, Washington. Approximately 140 miles upstream of Lower Granite Dam, Idaho Power Company operates the Hells Canyon Complex, a series of three dams on the Snake River.

The four lower Snake River dams—Lower Granite, Little Goose, Lower Monumental, and Ice Harbor—are located along the lower 140 miles of the river extending west from Lewiston, Idaho (Figure 4.1-1). The Palouse and Tucannon rivers are the major tributaries below Lewiston. Both of these tributary rivers enter the lower Snake River behind Lower Monumental Dam. Only 5 percent of the Snake River's total drainage area is located downstream of its confluence with the Clearwater River.

The Snake River Basin encompasses a 109,000-square-mile area shared by several states including Wyoming, Montana, Oregon, Idaho, and Washington. Several complex systems of mountain ranges, with intervening valleys and plains, lie within the Snake River Basin. Much of the southern part of the basin is included within the Columbia Plateau Province, a semiarid expanse formed by successive flows of basaltic lava. A rugged area of mountain ridges and troughs, with deeply incised stream channels, lies north of this plateau. Elevations in the basin range from 13,766 feet above mean sea level (msl) at Grand Teton Mountain in Wyoming to



Special Note: Dams may not all be operational or currently in use.

REGIONAL DAMS

Federal Columbia River Power System (FCRPS)

Other Federal, State, & Private

BOUNDARIES

Columbia River Basin

State

County

KM 100 50 0 MILES 50 100

1,000,000 ACRES

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

1 : 76,032,000

DRAFT

Lower Snake River
Juvenile Salmon Migration Feasibility Study

Figure 4.1–1.
REGIONAL DAMS

GIS Analysts & Graphic Assembly: Applied Technology Team (CENWW-PM-PD-E)
g:\regional\r2k\plates\lsr\jsmeis\crb\crbdm.dgn:GISFILE PLOTTED: 07 DEC 1999

1999

approximately 330 feet msl at the lower Snake River's confluence with the Columbia River.

4.1.2 Human Environment

The Snake River Basin has a rich and diverse landscape with areas of scenic beauty characterized by mountain ranges, plateaus, and large river valleys. The forests and mountains in the Pacific Northwest, in general, have abundant and diverse aquatic, terrestial, and wildlife resources, and many outstanding natural and scenic features. Water-related settings range from wilderness mountain lakes and streams to urban waterfront parks. Land use in the Snake River Basin is strongly influenced by a variety of Federal, state and private land ownership, water availability, and land productivity. Land use in the basin includes tremendous amounts of agricultural land in cropland. Large areas of publicly-owned land provide a significant proportion of the region's natural, recreational, and scenic resources.

Population growth in the region continues to be primarily in urban areas, such as the Tri-Cities and Spokane, Washington; and Boise, Nampa, and Caldwell, Idaho. The remaining areas are sparsely populated because large tracts of land are devoted to agriculture, forestry, and livestock grazing. The basin population is culturally diverse. Native Americans are a widespread cultural group with direct ties to the Snake River System spanning many generations. Persons of Hispanic origin comprise a rapidly growing portion of the population in areas surrounding the lower Snake River. There are also a variety of active community or industry based groups in the basin area, including groups representing river transporters, irrigators, the aluminum industry, commercial fisheries, sports fisheries, farming communities, and environmental interests.

The regional economy has experienced some transition over the past decade or so, evolving from being primarily resource-based to a more diverse economy, with growing trade and service sectors. The Snake River continues to provide a variety of resource uses, including transportation, electric power generation, recreation, and irrigation. The lower Snake River transportation system consists of navigation channels and locks, port facilities, and shipping operations. This system provides a key transportation link to the eastern interior region of the lower Columbia River Basin. Grain harvested in eastern Washington, throughout Idaho, and as far away as North Dakota is transported on the lower Snake River by barge. The majority of these shipments are shipped to ports on the deep-draft portion of the lower Columbia River for export. Power generated by the four lower Snake River dams serves residential, commercial, agricultural, and industrial loads. Recreational opportunities at developed sites along the lower Snake River Reservoirs include camping and picnicking, swimming, boating, fishing, and windsurfing. Approximately 37,000 acres of cropland are irrigated from Ice Harbor Reservoir. Municipalities draw water from the lower Snake River reservoirs for their water supplies. Water is also withdrawn to irrigate vegetation for wildlife and is used for some commercial uses or as a source of outfall for municipal and industrial effluents.

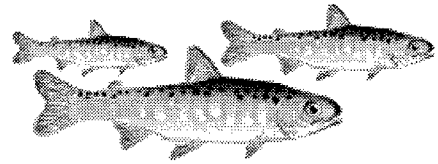
The harvest of Columbia River and Snake River anadromous fish has been a important human activity throughout history. Native American, non-native commercial, and sport anadromous fisheries have all experienced large declines in

harvest levels from before the turn of the century. Incomes generated by salmon harvest have varied accordingly, but continue to be strong elements of some local economies in Oregon and Washington, and for the treaty tribes.

4.1.3 Climate

The climate of the lower Snake River Basin is greatly influenced by prevailing westerly winds and the Cascade and Rocky Mountain ranges. The Rocky Mountains shield this section of Washington from the more severe winter storms that move southward across Canada, while the Cascade Range forms a barrier to the easterly movement of moist air from the Pacific Ocean.

Precipitation generally increases in an easterly direction across the lower Snake River canyon. Average annual precipitation ranges from approximately 11 inches in the lower elevations near the western edge of the study area to 23 inches in the higher elevations near the Idaho border. Most of the winter precipitation between December and mid-February is snow. The average annual snowfall ranges from 25 inches in western Whitman County to 35 inches in the eastern part of the canyon. The area is typically warm and sunny in the summer, with average summer high temperatures ranging from 80 °F to 90°F. Precipitation is light during the summer.



4.2 Geology and Soils

4.2.1 Introduction

This section presents background information on the regional geology of the lower Snake River and, in more detail, on the shoreline geology of the reservoirs affected by the alternatives. Areas with specific geologic hazards (e.g., landslides along reservoir shorelines) or surficial deposits (loess) susceptible to impact by the alternatives are also described. Emphasis is placed upon the existing and historical conditions of the geologic materials.

4.2.2 Regional Geology

The Columbia Plateau is drained by two principal rivers, the Snake River in the south, and the Columbia River in the north and west portions of the plateau. The source of the Columbia River is in the Columbia Mountains in British Columbia. The source of the Snake River is in Yellowstone National Park in northwestern Wyoming. From Wyoming, it flows across the southern part of Idaho to the Oregon-Idaho border. Here it turns north, flowing through Hells Canyon, a mile-deep canyon cut through the Seven Devils Mountain Range. At Lewiston, Idaho, the Snake River is joined by the Clearwater River, and it abruptly turns west along the base of a fault scarp entering the Columbia Plateau. After following the scarp for 10 miles, it swings northwestward on the first segment of a large radius arc. The river has entrenched itself in the plateau surface to a depth of 2,000 feet. The larger tributary streams entering the Snake River between Lewiston, Idaho and its mouth are the Palouse River and Tucannon River. Both of these tributary rivers enter the Snake River behind Lower Monumental Dam.

The predominant rock type of the Columbia Plateau is a thick sequence of Miocene flood basalts collectively named the Columbia River Basalt Group (CRBG). The Miocene epoch is a division of geologic time that represents the earth history between 5 and 24 million years before present (BP). However, the Snake River drainage contains rocks of many different geologic time periods, from PreCambrian (over 570 million years BP) to Recent. Rock types range from limestones and shales to metamorphic rocks. The basalt lava flows of the CRBG were extruded through a series of north-trending fissures now preserved as dikes, principally in the southeast corner of Washington and the northeast

corner of Oregon. The deposits spread out across the plateau as a series of basalt flows ranging in thickness from a few feet to more than 300 feet. Between the series of basalt flows, clastic and volcanic sediments were deposited along the plateau margins and in subbasins. Much like today, the original surface on which the basalt flowed was highly irregular as the area was surrounded by the Rocky Mountains, Blue Mountains, and Cascade Mountains. The basalt flows settled in lower regions abutting the flanks of the highlands to the east and north. The basalt flows arch upward to the crest of the Blue Mountains in the south. The cumulative thickness of the lava flows in the Pasco Basin is greater than 10,000 feet (Hooper and Swanson, 1987).

The CRBG is overlain by Pliocene (2 to 5 million years BP) and Pleistocene (10,000 years BP) sedimentary deposits. These deposits range from coarse to fine, dirty gravels derived from weathering of the Blue Mountains, to fine silty lake bed sediments which were deposited in local basins formed during the Pliocene.

One of the major geologic events that had a significant influence on the shaping of the current landscape in the lower Snake River area of the Columbia Plateau was the periodic breaching of the ancient glacial Lake Missoula during the Pleistocene. This ancient glacial lake was formed near the terminus of the continental ice sheets in northern Idaho and western Montana. During these catastrophic events, floodwaters cascaded across the Columbia Plateau surface, stripping soil and gouging large linear grooves into the bedrock, forming coulees, and depositing large, bouldery gravel bars along major stream drainages and in basins.

The catastrophic floods eroded the river valleys and produced large deposits of river sediments (Baker et al., 1987). These river deposits are found today on scattered terraces along river valleys. The flood erosion also produced steep slopes that have undergone some retreat, producing steep, coarse-grained talus slopes along the bedrock cliffs. Post glacial river incision has reworked some of the older river deposits, producing lower elevation and younger alluvial terraces that are distributed along the rivers. Since impoundment of the lower Snake and Columbia rivers, some smaller tributary streams and rivers have deposited alluvial fans where they enter the reservoirs; others are completely drowned, forming small embayments. All of the Pleistocene and contemporary river and alluvial deposits consist of gravels and sands with minor amounts of silts and clays.

During the Pleistocene and into the post-glacial period, winds eroded exposed fine grained sediments. These silt-sized sediments, known as loess, have been deposited over large areas. These deposits are most common on the upland surfaces of the Columbia Basalt Plain in a region known as the Palouse (Busacca et al., 1985). These materials occur only to a minor extent around the perimeter of the lower Snake River reservoirs. Near Ice Harbor Dam, there is a large wind-derived sand deposit (Miklancic, 1989) and small areas of other sand deposits exist along some reservoirs.

4.2.3 Regional Soils

The soils along the lower Snake River can be primarily divided into three types: upland soils along the hillslopes and canyons, alluvial soils along the river, and bench soils along the ridgetops and terraces above the river. The upland soils are primarily shallow to very deep silty loam soils formed from loess deposits and residuum from basalt. These soils tend to have a high-to-severe erosion hazard due to rapid runoff along the steep slopes of the canyon. The bench-type soils tend to be sandy loam developed from

glacial outwash, loess, volcanic ash, and basalt. These bench-type soils have slow runoff characteristics and slight erosion hazards because they tend to be on less steep slopes. Alluvial soils are found in the valley bottom and are excessively drained and range from cobbley coarse sand underlain by stratified cobbles, boulders, gravels, and sand. These alluvial soils were more subject to periodic flooding prior to river impoundment.

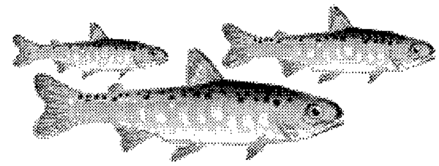
Many of the Snake River Plateau soils are light and highly erodible with low rainfall limiting the ability of vegetative cover to reestablish, once removed. Wind erosion is prevalent, especially during the spring and fall, when high winds and dry soil conditions create dust storms. The severity of these dust storms is exacerbated by dryland agricultural practices that expose the soil during spring cultivation and fall harvesting.

4.2.4 Erosion and Sedimentation

The lower Snake River downstream of Lewiston, Idaho annually transports approximately 3 to 4 million cubic yards of new sediments which have been eroded from its drainage basin. Approximately 100 to 150 million cubic yards of sediment have been deposited upstream of the four lower Snake River dams since Ice Harbor became operational in the early 1960s (Corps, 1998a).

Since the construction of dams and the creation of slackwater reservoirs, there has been little sediment transport downstream of Lower Granite Dam. Sedimentation within the lower Snake River reservoirs is dominated by small streams and rivers which drain into the reservoirs, and by wave-eroded materials. The heavier sediments, gravels, and sands can no longer be transported beyond the length of each reservoir. Lighter sediments, silts, and clays move through the spillways, fishways, and powerhouses. River erosion is concentrated within a narrow band between high and low pool levels along the upper reservoir shorelines.

Landslides of various types occur along the reservoir shorelines. These landslides are generally within the surface layer sediments, especially those that are somewhat poorly drained because of an admixture of finer grained sediment.



4.3 Air Quality

The air quality of the lower Snake River Basin generally meets standards established under the Clean Air Act (CAA). Sources of air pollution in the region include area sources such as agricultural fields that are susceptible to wind erosion, and point sources such as industrial emission stacks. This section discusses air quality regulations, sources of air pollution in the lower Snake River Basin, and climatic factors that may affect air quality. The information provided is taken from Technical Appendix P, Air Quality, and the Lower Snake River Biological Drawdown Test Final EIS (Corps and NMFS, 1994).

4.3.1 Air Quality Regulations

4.3.1.1 Regulated Air Pollutants

The CAA requires the U.S. Environmental Protection Agency (EPA) to set ambient air quality standards (AAQSs) to protect the public health and welfare. Standards to protect public health (primary standards) must provide for the most sensitive individuals and allow a margin of safety, without regard to the cost of achieving the standards. When a health standard does not protect public property or resources (public welfare), a secondary standard may be established which is more restrictive than the primary standard, but which takes into account other factors including cost and technical feasibility to achieve the standard. Air quality standards have been established for carbon monoxide (CO), lead (Pb), particulate matter with aerodynamic diameters less than 10 micrometers (PM_{10}), nitrogen dioxide (NO_2), ozone (O_3), and sulfur dioxide (SO_2). Geographic areas with measured pollutant concentrations greater than the AAQSs are referred to as nonattainment areas.

The EPA has delegated several air quality regulatory responsibilities to state and local agencies. The state and local responsibilities include enforcing national and state AAQSs, ensuring human health protection from toxic air pollutants (TAPs), and mitigating nuisances caused by windblown dust. In Washington, the State Department of Ecology (Ecology) enforces AAQSs and regulates emissions of TAPs. Ecology also regulates emissions from large combustion sources such as power plants, and reviews

new sources of air emissions. Local air pollution authorities regulate fugitive emissions, which are emissions from sources other than industrial vents and stacks (e.g., windblown dust). Local air control programs also regulate particulate matter by placing restrictions on woodsmoke, open burning, industrial operations, and other activities.

4.3.1.2 Greenhouse Gases

Emissions of greenhouse gases (GHGs) are addressed by the U.S. Climate Change Action Plan (CCAP), introduced in 1993, which seeks to reduce GHG emissions in the United States to their 1990 levels by 2000. Under the CCAP, individual states play a critical role in reducing GHG emissions. Washington State's CCAP, created in partnership with the EPA, sets the goal to stabilize GHG emissions through an 18 million ton reduction from "business as usual" by 2010. GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFC), partially halogenated fluorocarbons (HCFC), and O_3. Increased concentrations of GHGs enhance the atmosphere's ability to retain heat.

4.3.2 Sources of Air Pollution

The air quality in the lower Snake River region generally continues to meet the AAQSs. Components of the air quality environment include emission sources, ambient air pollutant concentrations (as measured by a sampling network), and climatic effects that govern the generation of fugitive dust and the behavior of emitted industrial emissions.

Potential sources of particulates within the region include area sources (e.g., dirt or gravel roads and plowed fields) and industrial point sources (e.g., manufacturing plants). The area sources are subject to wind erosion that results in blowing dust. Throughout the arid and semi-arid portions of eastern Washington, wind erosion is the primary cause of dust emissions. Windblown emissions are often associated with dryland farming, but are also produced by irrigated agriculture and nonagricultural sources such as exposed reservoir shorelines.

According to the U.S. Bureau of Reclamation (BOR) (1989), area sources are far more important than point sources in eastern Washington because of the prevalence of wind erosion. Wind erosion is greatest during the spring and fall, when high winds and dry soil conditions create dust storms of varying severity. Highway and road closures are sometimes necessary because of reduced visibility. The severity of dust storms can be exacerbated by dryland agricultural practices, which expose the soil during spring cultivation and fall harvesting.

Annual total suspended particulate readings at Pasco, Washington (based on a 12-month moving geometric mean concentration) ranged from 45 to 65 micrograms per cubic meter ($\mu g/m^3$) during the mid-1980s and in some years exceeded the Washington State annual standard of 60 $\mu g/m^3$. Over the same period, there were 2 to 4 days per year when particulate concentrations exceeded the 150 $\mu g/m^3$ standard for a 24-hour period (BOR, 1989).

While the above conditions and measurements apply specifically to eastern Washington and the Pasco area, they are likely to be representative of all the lower Snake River reservoirs. Extensive agricultural areas around or near the lower Snake River reservoirs could contribute to fugitive emissions.

The primary source of gaseous criteria air pollutants, TAPs, and GHGs in the lower Snake River Basin is industrial emissions. Typical manufacturing plant emissions include soot and fine wood particles. Major stationary emission sources—emission rates greater than 100 tons per year (TPY)—within 31 miles of the four lower Snake River dams are located in Benton, Franklin, Walla Walla, and Whitman counties. Table 4.3-1 lists emissions data for local major sources in these counties, for the most recent reporting year available (EPA, 1998a).

Table 4.3-1. Major Air Emission Sources within the Lower Snake River Region

	Source		Emissions (TPY)			
County	City	Facility	NO_2	PM_{10}	SO_2	VOC
Benton	Plymouth	Northwest Pipeline	192			
	Benton City	A & B Asphalt		177		
	Kennewick	Harvest States Corp.		126		
	Richland	Acme Materials		104		
Franklin	Pasco	Tidewater Terminal				1,427
	Pasco	Chevron Northeast				215
Walla	Starbucks	Pacific Gas	330			
	Wallula	Pacific Gas	326			
	Walla Walla	Crown Cork & Seal				297
Whitman	Pullman	Washington State	240		121	
Lath	Idaho	Potlatch Corp.	133			

Source: EPA, 1998a

Air quality is a particular concern around thermal power plants, which commonly emit CO, CO_2, NO_x, particulate matter (PM), and SO_2 as combustion by-products. All recent additions to Northwest thermal plant capacity have been natural gas-fired combined cycle combustion turbines. These plants use the least-polluting carbon fuel in highly efficient engines, in which chemical emissions can be effectively controlled.

4.3.3 Ambient Air Pollutant Concentrations

The air quality in Benton, Franklin, and Whitman counties achieves all state and national AAQSs, based on information from the nearest air pollution monitoring stations. The monitoring stations are located close to major air emissions sources. Therefore, the monitoring data are not representative of air quality at the project locations. There are few industrial sources in the areas of the four dams. Therefore, PM_{10} is the only pollutant of concern for the region. Air quality around Ice Harbor, Lower Monumental, Little Goose, and Lower Granite is probably better than PM_{10} monitoring data indicate.

Locations where measured pollutant concentrations are greater than the AAQSs are referred to as nonattainment areas. A small area encompassing Wallula, Washington is a PM_{10} nonattainment area. Wallula is about 11 miles south of Ice Harbor Dam. The air quality problem associated with the Wallula nonattainment area appears to be related to industrial emissions and fugitive dust.

4.3.4 Climatic Factors

Air quality is influenced by climatic factors including precipitation, temperature, and wind conditions. In the case of windblown dust, the greatest potential for occurrence coincides with periods of low relative humidity, extended sunshine, and warm to hot temperatures. Dry, loose soils and sediments become airborne during high wind events. Surface particles are much less mobile if the ground is wet or frozen. In the case of industrial emission point sources such as thermal powerplants, maximum air pollutant concentrations are a consequence of low wind speeds and very stable atmospheric conditions. The final height of a plume emitted from a stack is a function of the effects of momentum and buoyancy. Greater plume rise is usually achieved with colder ambient temperatures.

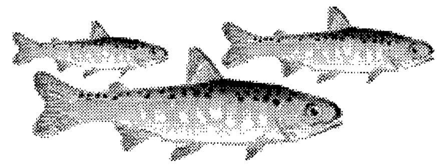
Climatic conditions in the lower Snake River area are characterized by large seasonal temperature differences, low precipitation, and relatively minimal cloud cover. Valley bottoms along the Snake River record some of the highest summer temperatures in the region, and they tend to stay slightly warmer than surrounding upland areas in the winter.

Precipitation is typically concentrated in the late fall, winter, and early spring, with more arid conditions prevailing from late spring through the summer. The reservoirs on the middle and lower Snake River generally experience measurable precipitation on 90 to 120 days per year (Jackson and Kimerling, 1993).

The prevailing wind direction in southeastern Washington is from the southwest in both winter and summer. Average wind speeds throughout the basin are generally in the range of 7 to 8 miles per hour. Some locations have considerably higher wind speeds (Jackson and Kimerling, 1993).

Infrequent July and August thunderstorms, which usually drop only small amounts of rain, are sometimes accompanied by strong wind gusts. Winter weather conditions often produce strong winds in the region. Local winds in the reservoir areas are often channeled parallel to the shoreline by the river valleys. Local topography can also act as a funnel that increases wind speeds. A daily cycle of changing up-valley and down-valley local wind directions can be common, particularly in mountain areas.

Average wind speeds and peak gust speeds recorded at selected meteorological monitoring stations in the basin are relatively high. These characteristics represent significant potential for windblown dust, if soil or sediments are exposed. Much of the interior plateau area near the Columbia and Snake rivers is dominated by fine-grained loessal soils that are particularly susceptible to wind erosion (Jackson and Kimerling, 1993).



4.4 Water Resources

4.4.1 Hydrology

4.4.1.1 Climate

The climate of the lower Snake River study area is greatly influenced by prevailing westerly winds and the Cascade and Rocky Mountain ranges. Most of the air masses and weather systems crossing the area are influenced by these winds. Dry continental air masses occasionally enter the region from the north or east. This air from the continent results in low humidity and high temperatures during the summer, while in the winter the weather is clear, cold, and dry. Climate data for Lewiston, Idaho, and Pasco, Washington are presented in Table 4.4-1.

Precipitation generally increases in an easterly direction across the lower Snake River canyon. Average annual precipitation ranges from approximately 11 inches in the lower elevations near the western edge of the study area to 23 inches in the higher elevations near the Idaho border. Average annual snowfall ranges from 25 inches in western Whitman County to 35 inches in the eastern part of the canyon. A chinook wind or rain on a snow cover sometimes results in rapid melting, heavy runoff, and flooding along the larger streams (Donaldson, 1980). Precipitation is light during the summer and average summer high temperatures range from 80 to 90°F.

Table 4.4-1. Climate Data for the Lower Snake River Study Area

	Lewiston, ID				Ice Harbor Dam			
	Temperature		Precipitation		Temperature		Precipitation	
	Average Daily Maximum (°F)	Average Daily Minimum (°F)	Average (inches)	Average Snowfall (inches)	Average Daily Maximum (°F)	Average Daily Minimum (°F)	Average (inches)	Average Snowfall (inches)
January	39.3	26.3	2.58	19.6	40.1	27.0	1.10	2.5
February	46.4	30.6	1.53	11.5	48.5	30.2	0.88	1.1
March	52.6	32.8	1.89	10.2	57.4	34.6	0.97	0.1
April	61.5	38.4	1.79	1.4	65.2	40.2	0.68	0
May	70.7	45.8	2.05	0.2	73.3	47.1	0.83	0
June	79.1	52.8	1.95	0	81.5	54.0	0.61	0
July	89.5	58.6	0.77	0	89.0	59.2	0.21	0
August	87.4	57.4	1.18	0	88.4	59.2	0.45	0
September	77.4	49.6	1.16	0	79.6	50.5	0.47	0
October	62.9	40.4	1.41	0.6	66.7	40.9	0.67	0
November	47.7	32.7	2.18	8.1	51.5	34.7	1.35	0.2
December	41.1	28.5	2.26	15.9	41.4	27.9	1.45	2.1
Annual Average	**63.0**	**41.2**	**20.75**	**67.5**	**65.3**	**42.1**	**9.67**	**5.9**

4.4.1.2 Description and Hydrology of Drainage Area

The Snake River is the principal tributary of the Columbia River and winds its way 1,078 miles to the confluence with the Columbia River near Pasco, Washington. The major tributaries to the lower Snake River are the Clearwater, Palouse, and Tucannon rivers. The Clearwater River, the largest tributary to the lower Snake River segment, historically contributes about 39 percent of the combined flow in the lower Snake River reach (Corps, 1995a). Flows from the Clearwater, along with recent releases from Dworshak Dam, make up close to 50 percent of the lower Snake River flows during periods of low flow. The Palouse and Tucannon rivers drain into Lake Sacajawea behind Lower Monumental Dam and generally make up less than 1.5 percent of the Snake River flow.

The Snake River drainage basin covers an area of more than 109,000 square miles (Table 4.4-2). Approximately 9.6 million acre-feet (MAF) of water from numerous artificial reservoirs and partially controlled lakes in the Snake River Basin have a substantial effect on the flow characteristics of the lower Snake River. Dworshak Reservoir on the Clearwater River in Idaho has the greatest usable storage capacity with approximately 2 MAF. The mean annual flow at Ice Harbor is more than 51,000 cubic feet per second (51 kcfs), corresponding to a volume of about 37 MAF. Minimum and maximum flows vary considerably as indicated in the summary hydrographs at Ice Harbor and Lower Granite (Figures 4.4-1a and 4.4-1b). Average mean daily flows are at minimum from the mid-summer (mid-July) to the early fall (mid-October). Average mean daily flows are at maximum from mid-May to mid-June due to the spring snow runoff. A description of low, average, and high flow years (1994, 1995, 1997 respectively) are described in Appendix F, Hydrology/Hydraulics and Sedimentation.

Table 4.4-2. Snake River Drainage Characteristics

Drainage Area Location	Period of Record	Mean Annual Runoff Drainage Area (sq. mi.)	Mean Flow (cfs)	MAF
Snake River at Brownlee Dam	1928-1989[1/]	72,590	19,210	14
Salmon River at Whitebird	1919-1989[2/]	13,550	11,250	8
Clearwater River at Spalding	1925-1989[2/]	9,570	15,320	11
Snake River at Lower Granite Dam	1928-1989[1/]	103,500	50,730	37
Snake River at Ice Harbor Dam	1928-1989[1/]	108,500	51,050	37

1/ BPA, Seasonal Volumes and Statistics, Columbia River Basin

2/ U.S. Geological Survey, Water Resources Data, Idaho

4.4.1.3 Historical Flows Prior to Impoundment

Prior to the impoundment of the lower Snake River and much of the Snake River drainage (before 1900), water levels were uncontrolled and fluctuated naturally as the river's discharge varied throughout the year. The difference in vertical distance measured at gauging stations near Clarkston and Riparia reflect the natural water level fluctuations of the river. Natural water level fluctuations varied between 20 feet and 30 feet above summer base flows.

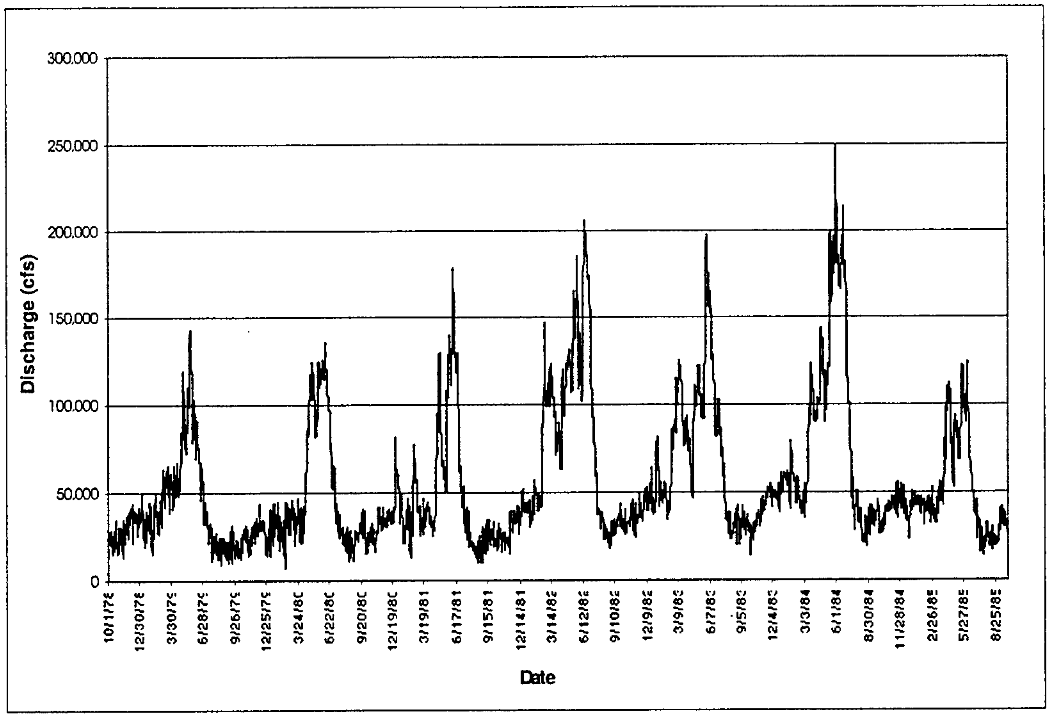


Figure 4.4-1a. Average Daily Flows for Lower Granite Dam, 10/1/78 to 10/1/85

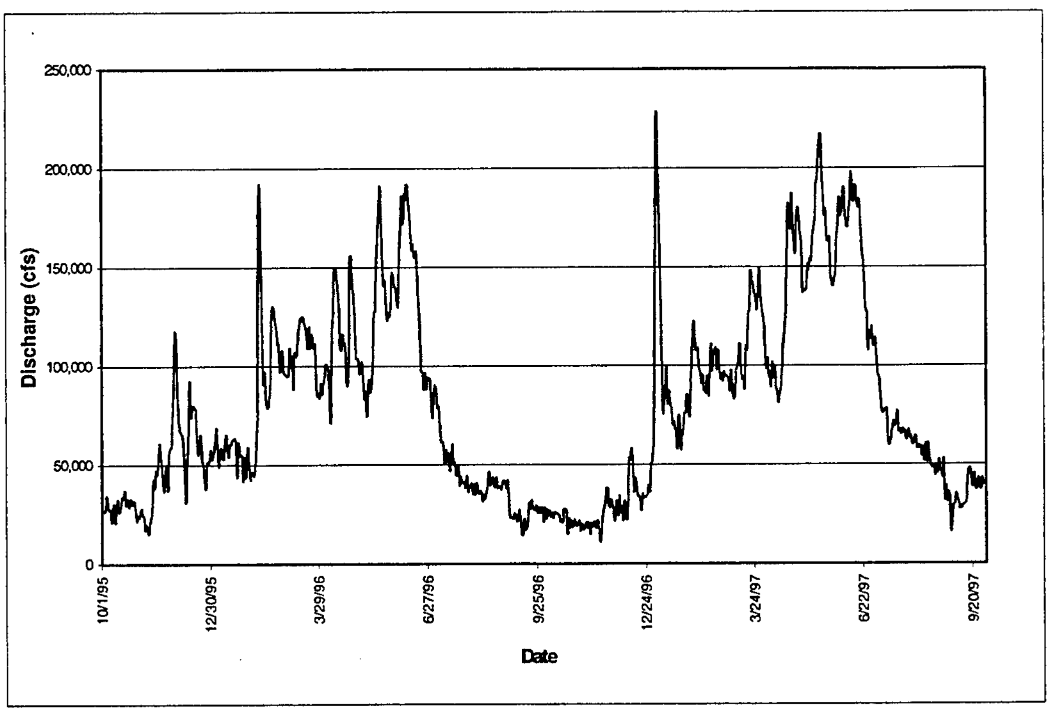


Figure 4.4-1b. Average Daily Flows for Ice Harbor Dam, 10/1/95 to 10/1/97

4.4.2 Water Quality

The lower Snake River watershed encompasses a 109,000-square-mile area shared by Wyoming, Oregon, Idaho, and Washington. The major tributaries to the Snake River include the Salmon, Clearwater, Boise, Owyhee, Grande Ronde, Palouse, and Tucannon. Each state has its own water quality standards, and management and monitoring programs. The waterways in each state are also regulated by several Federal, state, tribal, and local agencies, each having responsibilities for water rights, allocation, flows, and operation of the system.

This section describes the physical properties and chemical constituents of water, which serve as the primary means for monitoring and evaluating water quality. Water quality is measured by many parameters, but for the areas of concern, the most important are stream water temperature; sediment-related water parameters such as suspended sediment and turbidity; dissolved oxygen (DO), pH; and nutrients such as nitrates and phosphates. A map of the water quality monitoring stations is displayed in Figure 4.4-2. Table 4.4-3 displays the current Washington water quality standards for parameters of concern.

4.4.2.1 Activities in the Lower Snake River Affecting Water Quality

Dams and Hydropower

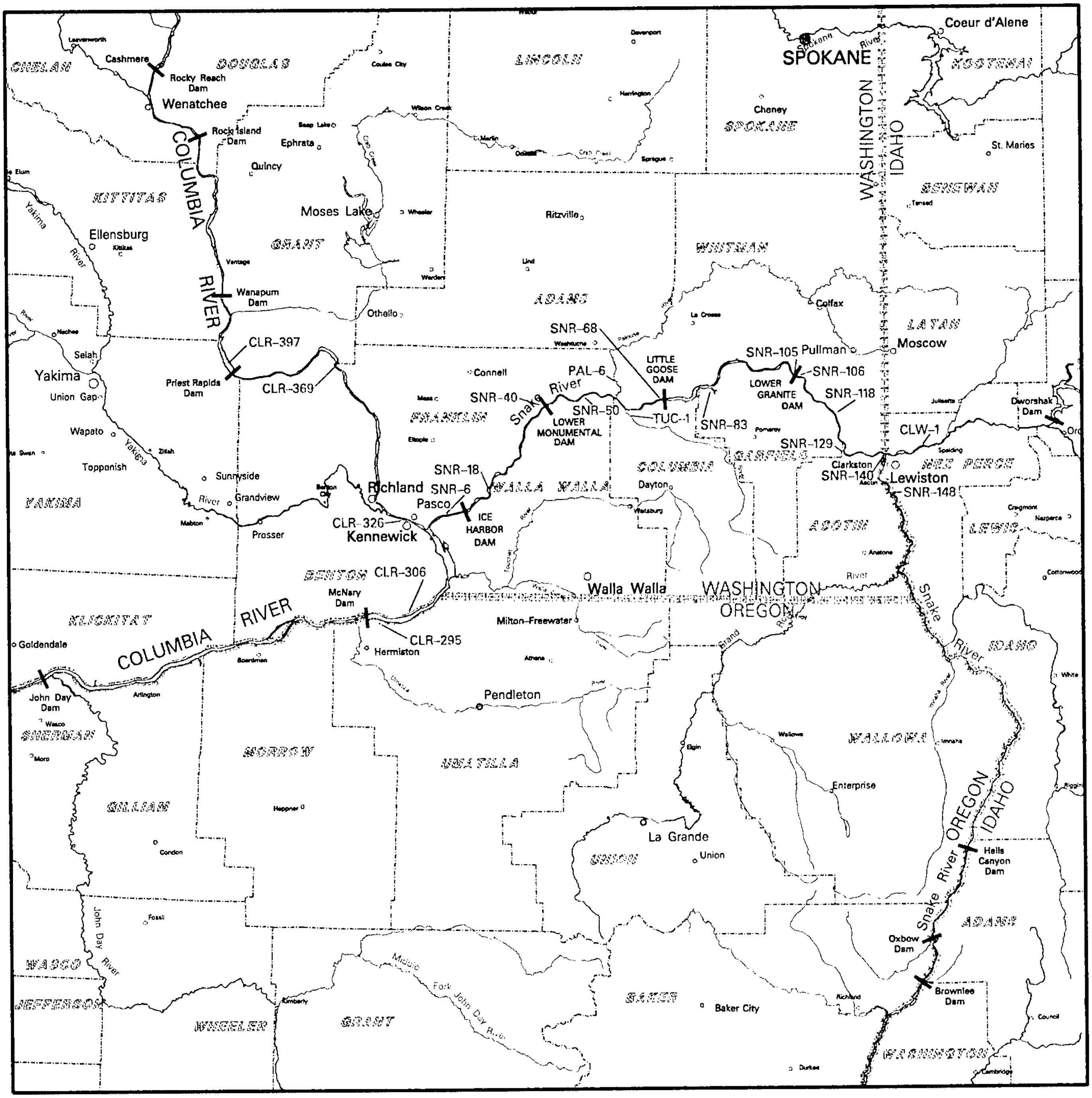
Two of the project uses of dams constructed on the lower Snake River include navigation and hydropower. The dams impound water and reduce river velocity. As a result, sediment settles on the bottom of the reservoir or remains suspended in the reservoir's water column, affecting turbidity and concentrations of contaminants in the reservoir or downstream. Sediment transport downstream of dams is affected because natural sediment movement is interrupted by the dams.

Dam operations could result in downstream scouring, increased gas supersaturation, decreased DO in deeper water, increased turbidity, and re-suspension of contaminated fine sediments. Upstream impacts may include decreased water volumes and flows, decreased DO concentrations, increased pollutant concentrations, and altered mixing of outfall discharges.

Water released through spillways and heating (solar and geological) can also increase total dissolved concentrations which can cause gas bubble disease (gas supersaturation) in fish. Gas bubble disease can kill fish and may cause behavioral disorders. Fish tolerance to elevated gas pressure varies with fish species, life history stage, water temperature, hardness, depth, and length of exposure.

Reservoirs may also affect water temperature. After a stream is impounded, more surface area becomes exposed to solar radiation, precipitation, evaporation, and wind effects. At the microclimate level and depending upon local conditions and mesoscale meteorological elements, new lakes may have some influence over weather and climate.

Creation of large deep-storage reservoirs normally causes stratification or layers of water with different physical and chemical properties. The lower Snake River dams are run-of-river dams defined by their rate of water replacement or retention and do not stratify during any season of the year like storage reservoirs. The lower Snake River reservoirs



RIVER TRANSECT INDICATORS

BOUNDARIES

State

County

KM 300 100 0

MILES 7.5 15 30

125,000 ACRES

1 : 1,900,800

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

DRAFT

Lower Snake River
Juvenile Salmon Migration Feasibility Study

Figure 4.4–2.
WATER QUALITY SAMPLING SITES

1999

GIS Analysts & Graphic Assembly: Applied Technology Team (CENWW-PM-PD-E)
g:\regional\reg\plates\lsr\jsmeis\lsrg\lsrgwq.dgn:GISFILE PLOTTED: 07 DEC 1999

Table 4.4-3. Washington Water Quality Standards for Parameters of Concern and 303(d) Listings

Water Quality Parameter	Washington State Standard (Class A, Good)	303(d) List
Total Dissolved Gas	Shall not exceed 110% of saturation at any point of sample collection.	Yes
Dissolved Oxygen	Shall exceed 8.0 mg/l.	No
pH	Shall be within 6.5 to 8.5 with a human-caused variation within the above range of less than 0.5 unit.	No
Temperature	Shall not exceed 68°F due to human activities.	Yes
Turbidity	Shall not exceed 5 NTUs over background when the background level is 50 NTUs or less, nor increase more than 10% of background when the background level is 50 NTUs or more.	
Fecal Coliform	Shall both not exceed a geometric mean of 100 colonies/100 ml, and not have more than 10% of all samples obtained for the geometric mean value exceeding 200 colonies/100 ml.	No
DDT (and metabolites)	Acute[1/]: Shall not exceed instantaneous concentration of 1.1 µg/l at any time. Chronic[2/]: Shall not exceed concentration of 0.001 µg/l as any 24-hour average.	
Mercury	Acute[1/]: Shall not exceed a 1-hour concentration of 2.1 µg/l at any time. Chronic[2/]: Shall not exceed a 4-day average concentration of 0.012 µg/l more than once every 3 years on average.	
Glyphosate	EPA Maximum Contaminant Level goal is 0.7 mg/l (40 CFR Ch. 1 (7-1-99 Edition).	
Dioxin	EPA Maximum Contaminant Level goal is 0.00000003 mg/l (40 CFR Ch. 1 (7-1-99 Edition).	
Manganese	Concentrations greater than 150 µg/L impart an undesirable taste and browns laundry (EPA, 1976).	

1/ "Acute conditions": changes in the physical, chemical, or biologic environment which are expected or demonstrated to result in injury or death to an organism as a result of short-term exposure to the substance or detrimental environmental condition (WAC 173-201A-020, p. 1).

2/ "Chronic conditions": changes in the physical, chemical, or biologic environment which are expected or demonstrated to result in injury or death to an organism as a result of repeated or constant exposure over an extended period of time to a substance or detrimental environmental condition (WAC 173-201A-020, p. 1).

mg/l = milligrams per liter, NTU = Nephelometric Turbidity Unit, ml = milliliter, µg/l = micrograms per liter

may "grade" (Bennett et al., 1997) in temperature by a few degrees with increasing depth only when a higher volume of cold water released from a deep storage reservoir is augmented into a low inflow during summer and early fall (such as from Dworshak augmentation addressed in Bennett et al., 1997). The higher density of the colder water forms a wedge that is submerged below the warmer layer down to about 20 feet of depth in Lower Granite reservoir for a few miles downriver from the confluence input zone with the Clearwater River.

Flow releases from reservoirs are regulated by a series of operating rule curves designed to ensure that the dams perform their authorized functions. Actual releases, however, depend on runoff conditions. Generally, more water is stored and released during a high flow year than during a low flow year, resulting in different impacts to water quality in reservoirs and areas downstream from the dams. More flows also mean higher potential for spill. As most of the dams on the Snake and Columbia rivers are stair-step impoundments, the water moving downstream does not circulate sufficiently to rid itself of gas entrainment at the upstream dams. As a result, dissolved gas supersaturation created by spill at one dam will often stay at or above that initial saturation level as the water flows downstream.

Agriculture

The lower Snake River provides irrigation water for approximately 37,000 acres of farmlands, primarily from the Ice Harbor Reservoir. Water diverted for irrigation evaporates or transpires, seeps into the ground, or runs off the ends of fields, eventually returning to the river or tributaries as potential point or non-point pollution.

Livestock grazing adjacent to the Snake River can have a significant impact on water quality of the reservoirs and tributaries to the lower Snake River. Grazing adjacent to streams can destroy riparian habitat and vegetation necessary to shade streams and prevent erosion. Heavily grazed watersheds usually exhibit less holding capacity; this can result in increased runoff velocities. Increased runoff velocities can result in excessive erosion and sedimentation of streams.

Navigation and Transport

Transportation on the lower Snake River has been vital to the economy of the area. Wheat growers and many industries along the river depend on it to transport their products to market. Many large vessels and barges travel up and down the river daily, requiring channels deep enough for them to navigate (see Section 4.9, Transportation).

Dredging to maintain navigation channels affects the hydrology of the river channel and disturbs the channel bottom. It can increase the velocity of the current and the movement of suspended sediments which can scour the bottom and shoreline. Dredging also disturbs sediments that may contain toxic substances that can be harmful to plants and animals. Before dredging, the Corps typically tests for the presence of contaminants.

The possibility of accidental chemical spills, trucks and trains running parallel to the river exists. Barges and other vessels can have accidental spills of chemicals also. Most are small spills of gasoline, diesel, or oil but the potential for larger spills exists. Because of the size and velocity of the river, containment is very difficult. Depending on

the type of material spilled and the location, sections of the river could be adversely affected for many years.

Timber and Wood Product Industry

A large wood product facility is located on the Clearwater River, upstream of the confluence with the Snake River. Releases from this facility are permitted and regulated by various resource agencies.

4.4.2.2 Laws, Regulations, and Programs Related to Water Quality

Water quality studies and monitoring have been ongoing for many years in the lower Snake River by the Corps, U.S. Geological Survey (USGS), and the Washington State Department of Ecology (Ecology). Studies and monitoring are conducted to establish status and trends, and to assess watersheds. Eight long-term monitoring stations are located on the Snake River. Monitoring dates range from 1975 to 1998 and are located at Burbank, Washington; Ice Harbor, Washington; Lower Monumental, Washington; Little Goose, Washington; Lower Granite, Washington (RM 107); Lower Granite, Washington (RM 120); Anatone, Washington; and Weiser, Idaho, and Spaulding, Idaho on the Clearwater River (Figure 4.4-2).

The Corps monitors the water quality at four reservoirs. Routine parameters include flow, temperature, conductivity, nutrients, DO, pH, and dissolved gas. Sediment sampling is conducted in selected locations to assess sediment contaminants of concern. The Corps also conducts some biological monitoring in its reservoirs and some groundwater quality monitoring.

4.4.2.3 Water Quality Standards for Idaho, Washington, and Oregon

The EPA and Idaho, Washington, and Oregon have established surface water criteria or water quality standards for the Snake River. This discussion focuses on the state standards because they are the same or more stringent than the Federal criteria. The codes, rules, and regulations for these state standards are voluminous, so only selected highlights of the standards are presented in this document. Washington, Idaho, and Oregon have established a policy of anti-degradation and beneficial uses for their surface waters, which precludes the discharge or introduction of any toxic or hazardous materials that result in significant deleterious effects. Idaho's beneficial uses are domestic and agricultural water supply, cold water and warm water biota, salmonid spawning, primary and secondary contact recreation, and special resource water. All except warm water biota have been designated as beneficial for the Snake River downstream of Brownlee Reservoir and the north fork of the Clearwater River, and at Dworshak Reservoir.

Washington has a four-level water quality classification system that ranges from AA (extraordinary) to C (fair). The State of Washington has classified the lower Snake River as Class A (excellent). Beneficial uses are water supply (domestic, agricultural, and industrial); stock watering; fish and shellfish rearing, spawning, and harvesting; wildlife habitat; recreation (primary contact); and commerce and navigation. Oregon water quality standards would only apply to possible downstream impacts in the Columbia River such as McNary pool, a portion of which is in Oregon.

The water quality parameters that will be discussed in this section are significant for aquatic ecology and its relationship with the beneficial uses of water resources. These

parameters include DO, temperature, suspended sediments, turbidity, pH, and nutrients such as nitrogen and phosphorous. Water quality standards and 303(d) listings are displayed in Table 4.4-3.

Total Dissolved Gases

Total dissolved gas supersaturation can be caused when water passes through a dam's spillway. The spilling water carries trapped air deep into the waters of the plunge pool or "stilling basin" where increased hydrostatic pressure dissolves the air into the water. At depth, this dissolved gas is supersaturated compared to the conditions at the water's surface. If the supersaturated water is brought to the surface, the dissolved gas will either come out of solution and equilibrate with atmospheric conditions, or it will form bubbles. If the bubbles form within the tissues of aquatic organisms, they might injure or kill the organism. Since the dams have slowed the velocity, reduced the turbulence, and shortened the free-flowing sections of the river, the river cannot always equilibrate the excess dissolved air between the dams, and the supersaturation condition can persist for extended distances. This is especially true during periods of high flow and continuous spillage.

Saturation levels tend to progressively increase through the lower Snake River System as flows are successively released through each dam. The problem is exacerbated by the fact that dissolved gas saturation concentrations entering Lower Granite pool are already elevated and typically range from 105 to 110 percent due to releases from the middle Snake River dams and Dworshak Dam (Corps, 1995a). Installation of spillway deflectors at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor (in 1997 and 1998) dams has reduced total dissolved gas saturation levels to some degree; however, saturation concentrations above 100 percent and upwards to 140 percent are still being recorded during high flow events (Corps, 1995a).

For Washington, Idaho, and Oregon, a total dissolved gas standard of 110 percent saturation at ambient atmospheric pressure is the maximum concentration for acceptable total dissolved gas. However, in Washington, Ecology has waived the state standard for the four lower Snake River dams and has set an upper limit of 115 percent saturation in the forebays and 120 percent saturation in the tailwater. If the measured concentrations exceed these values based on a daily average of the 12 highest hourly measurements, then the spill release is curtailed to meet the limits. These dissolved gas criteria do not apply when the stream flow exceeds the 7-day, 10-year frequency flood. The Clearwater River to the Washington border, and the lower Snake River between the Clearwater River and Columbia River, have been placed on the EPA 303(d) list as water quality impaired for dissolved gas.

Dissolved Oxygen

DO refers to the concentration of oxygen dissolved in water. Adequate DO concentrations are important for supporting fish, invertebrates, and other aquatic life. Salmon and trout are particularly sensitive to reduced DO.

DO in water is dependent upon not only the saturation concentration, but the oxygen losses (sinks) and sources. The primary sinks are respiration and the biochemical oxygen demand (BOD) of substances in water. Major sources of DO include photosynthesis and dissolution of atmospheric oxygen in water as oxygen concentrations

are depleted (reaeration). Higher temperatures increase the rate of BOD (MacDonald et al., 1991).

The capacity of water to hold oxygen in solution is inversely proportional to temperature. For example, higher stream temperatures result in lower DO. In general, most forest streams have cool temperatures, rapid aeration rates, and relatively low oxygen demands. As a result, stream water is normally close to or at saturation. Full saturation does not usually occur in slow, low-gradient streams where the rate of aeration is slow; sites where fresh organic debris (particularly fine debris) causes a large BOD; or in warm, eutrophic streams where high levels of photosynthesis and respiration cause diurnal fluctuations in DO (MacDonald et al., 1991).

Minimum DO standards vary for each state. Idaho has specific criteria below existing dams. From June 15 to October 15, these criteria require at least 6.0 milligrams per liter (mg/l; 30-day mean), 4.7 mg/l (7-day minimum), 3.5 mg/l (instantaneous minimum), and 6 mg/l or 90 percent of saturation (whichever is greater) for salmonid spawning uses. In Washington, the DO for Class A waters must exceed 8.0 mg/l. Oregon specifies at least 90 percent saturation for its portions of the Columbia River. USGS data going back to 1975 indicate that low minimum DO concentrations less than 6 mg/l have been recorded in the Lower Granite pool (RM 107), in the Clearwater River (RM 11.6), and upstream of Weiser, Idaho.

The DO concentrations measured in 1997 at five monitoring stations along the Columbia and Snake rivers ranged from 7 mg/l to 12 mg/l over the summer months (June to October). The lowest DO concentrations occurred during mid-September when the average surface water temperatures were near maximum (Figure 4.4-3). The values represent DO concentrations averaged over the entire water column.

Temperature

Temperature plays an integral role in the biological productivity of streams. Aquatic organisms are highly sensitive to water temperatures. Salmonids and some amphibians appear to be the most sensitive to water temperatures and are used as indicator species regarding water temperature and water quality.

Idaho specifies temperature criteria in relation to specific use categories. The most restrictive use criterion is for salmonid spawning, with maximum water temperatures set at 55°F (12.8°C) with daily averages no greater than 48.2°F (9.0°C).

In Washington, no increase over 68°F (20°C) due to human activity is allowed. In the Snake River above the Clearwater River (RM 139.3), no increase over 0.54°F (0.3°C) caused by human activity can occur from a single source, or no increases over 2°F (1.1°C) from all activities when the stream is over 68°F (20°C). In the lower Snake River below the Clearwater River, water temperatures should not exceed 68°F (20°C) due to human activities. When natural conditions exceed 68°F (20°C), no temperature increase will be allowed that will raise water temperature by more than 0.54°F (1.1°C). In addition, no temperature increase in the lower Snake River should exceed $t=34/(T+9)$°C where t = change in temperature and T = background temperature. Oregon also does not allow water temperature increases in the Columbia River, outside of an assigned mixing zone, when the stream water temperature is at or above 68°F (20°C).

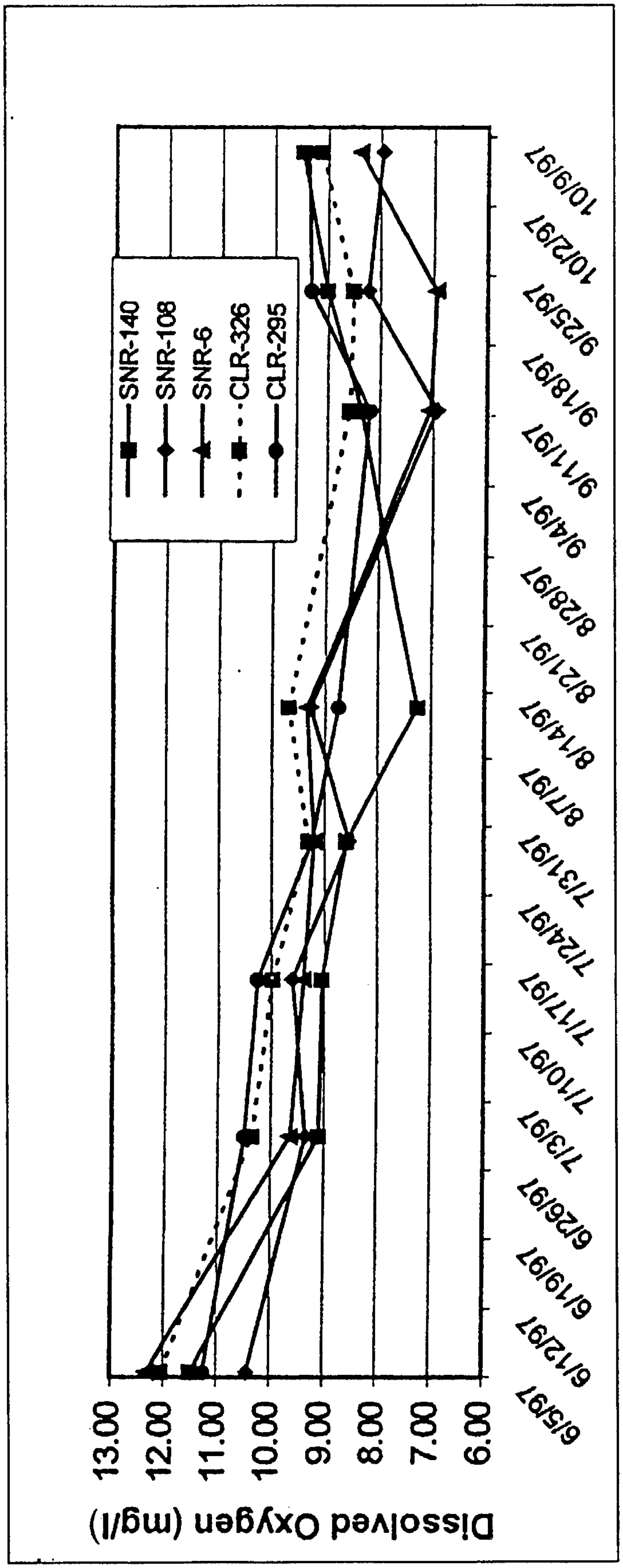


Figure 4.4-3. Dissolved Oxygen Data Measured in 1997 at Selected Sampling Stations Throughout the Study Area
(SNR—refers to Snake River Mile)
(CLR—refers to Columbia River Mile)

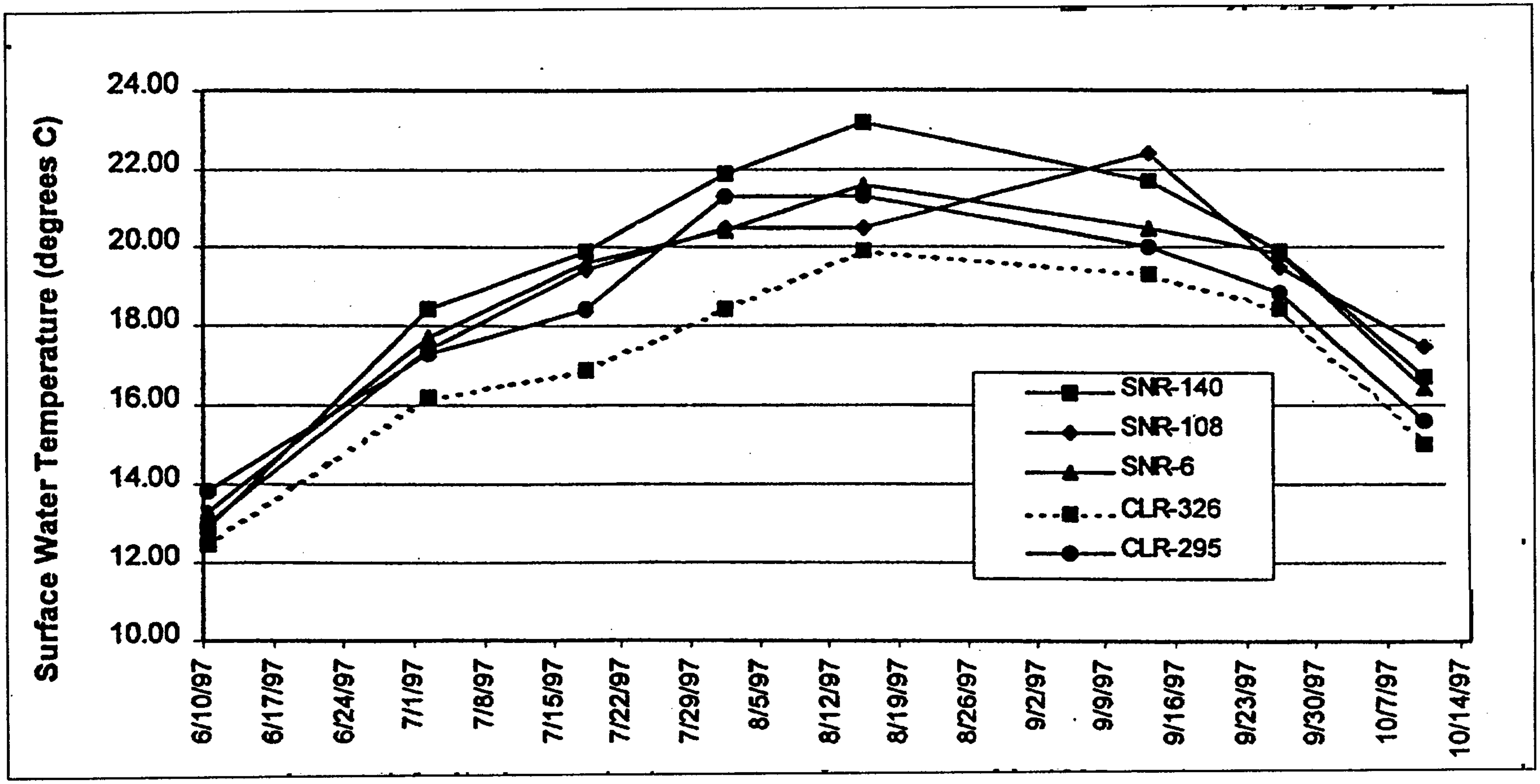


Figure 4.4-4. Surface Water Temperature Data Measured in 1997 at Selected Sampling Stations Throughout the Study Area
(SNR—refers to Snake River Mile)
(CLR—refers to Columbia River Mile)

The lower Snake River (from the Columbia River to the Clearwater River) has been 303(d) listed as water quality impaired by Ecology.

Based on an analysis of 1938 to 1966 USGS data, the effect of the hydropower system and other human-caused changes on temperature in the Columbia River became apparent in the mid-1950s before construction of the four lower Snake River dams, where Ice Harbor Dam was the first completed in 1961. The Hells Canyon complex of three dams was constructed in the 1950s through 1967. The major effect has been shifting temperature maximums so that warmer temperatures occur later in the year; maximum temperatures have shifted from occurring in mid-July through August to mid-August through September (EPA and NMFS, 1971; Corps, 1995b). Additional data collected prior to dam construction (1955-1958) indicates the maximum temperatures in the lower Snake River were frequently above 72°F (22°C) from mid-July to late August (FWPCA, 1967).

Temperature data from the five monitoring stations are displayed in Figure 4.4-4. Water temperatures in the lower Snake River are relatively cool in May and June during the peak flow and snowmelt period with typical readings ranging from 50 to 70°F (10 to 21°C). By mid to late-July, temperatures usually warm up near 68°F (20°C) or above and remain elevated until late September. The highest temperatures generally occur from August to mid-September (Corps, 1995b). Recent monitoring data for Lower Granite pool indicate that seasonal water temperature variations are controlled primarily by incoming solar radiation and ambient air temperatures. Flow rates have more of an effect on the duration of elevated temperatures within the growing season when the residence time of the water is greater in the reservoirs due to lower flow rates. The greater residence time in the reservoirs causes surface waters to warm up faster and also to cool down more slowly.

Dworshak Reservoir water has been used to augment flow to speed spring/summer chinook smolt passage rates and, secondary in priority, to control water temperature in the Snake River since July 1994. During 1994, the cooler water was released from Dworshak Dam for 48 days from May to mid-July. During this time period, the median flow contribution from the Clearwater River accounted for 54 percent of the total inflow to Lower Granite Reservoir. Based on temperature data collected from University of Idaho, the cold water releases resulted in a 11°F (6.2°C) drop in water temperature in the Lower Granite Reservoir at a depth of 20 feet (Bennett et al., 1997). In 1997, similar flow releases from Dworshak Dam apparently lowered the water temperatures in the Clearwater River by 3.6 to 5.4°F (2 to 3°C) and only 1.8 to 3.6°F (1 to 2°C) in Lower Granite Reservoir.

Sediment

Two of the most common water quality parameters measured and monitored for sediment are suspended sediment and turbidity. Both are related to sediment delivery and transport in hydrologic systems. Streams that exceed the water quality objectives for sediment-related water quality objectives would have high suspended-sediment delivery rates and/or turbidity. Approximately 100 to 150 million cubic yards of sediment have been deposited upstream of the four lower Snake River dams since Ice Harbor became operational in the early 1960s (Table 4.4-4). Under current conditions, Lower Granite is capturing an average inflowing sediment load of approximately 3 to 4 million cubic yards per year that the lower Snake River is carrying due to various runoff processes.

Table 4.4-4. Distribution of Sediment Carried by the Lower Snake River and Deposited in McNary and the Lower Snake River Project from 1953 through 1998

Project Name	Date in Service	Dates Project Impounded Sediment	Estimated Volume of Impounded Sediment[1/]
McNary	1953	1953-1961 (9 years)	27-36
Ice Harbor	1962	1962-1968 (7 years)	21-28
Lower Monumental	1969	1969-1970 (1 year)	3-4
Little Goose	1970	1971-1975 (5 years)	15-20
Lower Granite	1975	1975-1998 (24 years)	72-96
Total, McNary and Lower Snake		**46 Years**	**138-184**
Total, Lower Snake Project Only		**37 Years**	**111-148**

1/ measured in million cubic yards

Source: Technical Appendix E, Existing Systems and Major System Improvements Engineering

Suspended Sediment

Suspended sediment is the portion of the sediment load suspended in the water column. The grain size of suspended sediment is usually less than one millimeter in diameter (clays, silts, and fine sands), while particles greater than one millimeter are transported as bedload (Everest et al., 1987). During high peak flows (e.g., storm events) particles greater than one millimeter can be transported as suspended sediment (Sullivan et al., 1987).

Suspended sediment concentrations tend to be highest during the spring runoff and then decline as flows diminish through late summer and into fall. Figure 4.4-5 shows the suspended sediment at the five sample locations. The maximum suspended sediment concentrations tend to be lowest in the Clearwater River and upper Columbia River sites (8 to 16 mg/l) and approximately equal below Lower Granite Dam. Lower Granite Dam traps sediment transported by the Clearwater River and middle Snake River below Hells Canyon Dam. The maximum peak value measured was 65 mg/l above Lower Granite Dam at Snake River Mile (RM) 148 and averaged 28 mg/l in the surface waters of the lower Snake River during the same time interval. By mid-to late summer, concentrations drop to slightly above 5 mg/l on the lower Snake River. During the spring runoff, the Palouse and Tucannon rivers have much higher concentrations of 1,035 mg/l and 130 mg/l, respectively. During the summer months, the concentrations for both rivers drop below 15 mg/l.

Turbidity

Turbidity refers to the amount of light scattered or absorbed by a fluid. In streams, turbidity is usually a result of suspended particles of silts and clays, but also organic compounds, plankton, and microorganisms. Turbidity is measured in nephelometric turbidity units (NTUs). Although turbidity in a stream is highly variable and the relationship between turbidity and suspended sediment must be determined at each site, turbidity is regarded as the single most sensitive measure of land use on streams, mainly because relatively small changes in suspended sediment can cause a large change in turbidity.

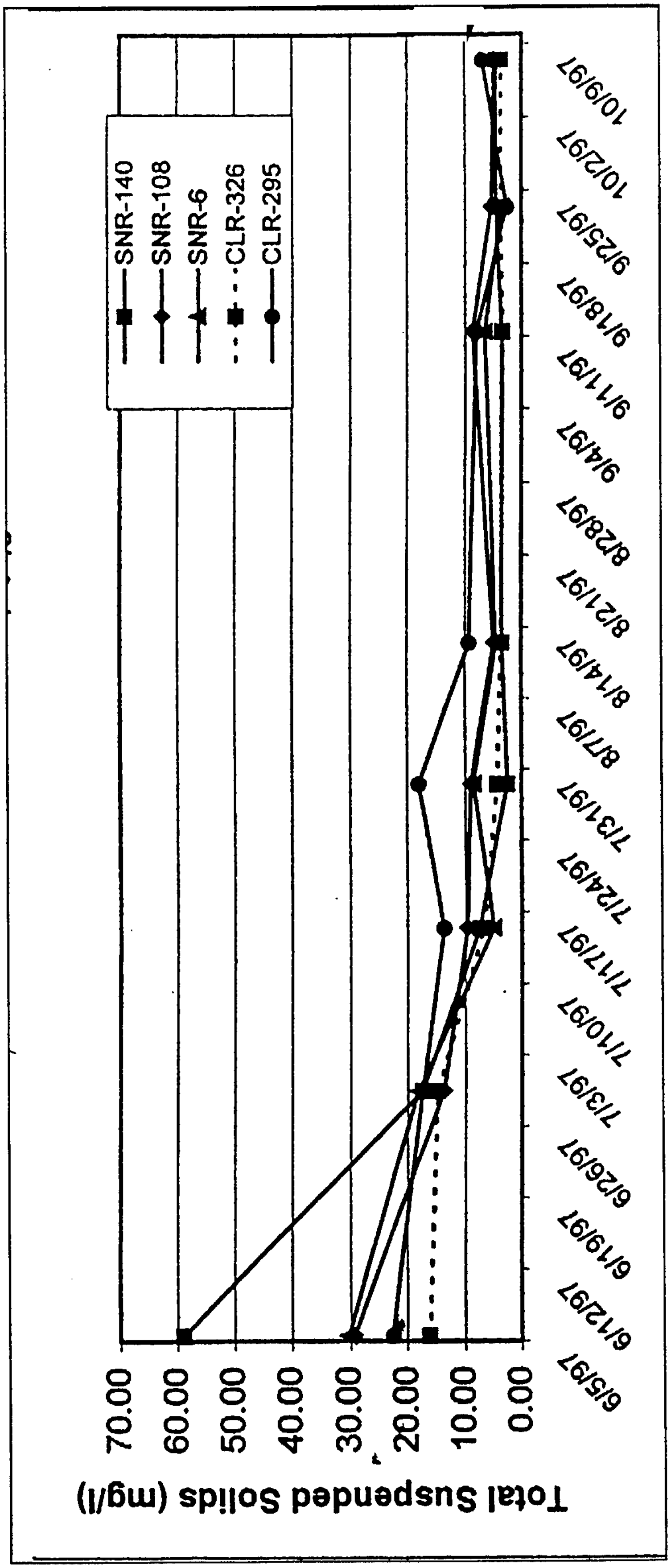


Figure 4.4-5. Total Suspended Solids Data Measured in 1997 at Selected Stations Throughout the Study Area
(SNR—refers to Snake River Mile)
(CLR—refers to Columbia River Mile)

Idaho and Washington specify that turbidity shall not exceed 5 NTUs over background levels when the background level is 50 NTUs or less, nor increase more than 10 percent when background is more than 50 NTUs. Oregon specifies that no more than a 10 percent increase over background is allowed. The turbidity in the lower Snake River has followed the same trends as the suspended sediment.

pH

As an index of the hydrogen ion concentration, pH is measured on a scale of 0 to 14. A value of 7 indicates a neutral condition; values less than 7 indicate acidic conditions; and values greater than 7 indicate alkaline conditions in water. The presence of carbonates, hydroxides, and bicarbonates decreases the acidity of water, while the presence of free mineral acids and carbonic acids increases its acidity. Acid mine drainage and industrial wastes that have not been neutralized may significantly lower the pH of water. A pH range from 6.5 to 8.3 pH units is acceptable in drinking water. For the protection of the aquatic environment, and for aesthetic and recreational use, the pH should be between 6.5 and 9 pH units. Washington, Idaho, and Oregon all require a pH within the range of 6.5 to 8.5 pH units with a human-caused variation less than 0.5 pH unit.

The median pH has ranged from 7.9 to 8.2 in the lower Snake River along water sampling locations. The Clearwater River has a median pH of 7.4 to 7.7, reflecting buffer capacity and reduced primary productivity compared to the lower Snake River. The Palouse and Tucannon rivers have slightly higher pH values than the lower Snake River.

Nutrients—Nitrogen and Phosphorus

Nitrogen and phosphorus are two elements that are important to plant growth such as primary production and possibly secondary production. The nitrogen to phosphorus ratio or balance in solution in the water determines the primary productivity of water bodies (WA DNR, 1997).

Nitrate is the predominant form in unpolluted water and ammonia may exist as an intermediate breakdown product of organic nitrogen, fertilizers, and animal wastes. Both ammonia and nitrate are readily taken up by aquatic biota, so an increase in nitrate concentrations upstream tends to diminish rapidly downstream. The primary concern with nitrates is that increased biological activity due to increased concentrations of nitrogen can deplete DO, which may adversely affect fish and other aquatic organisms (MacDonald et al., 1991).

Phosphorous can be separated into two fractions, dissolved and particulate. Dissolved phosphorous is found almost exclusively in the form of phosphate ions and these bind readily with other chemicals. The three main classes of phosphate compounds are orthophosphates, condensed phosphates, and organically bound phosphates. In general, only orthophosphates are readily available for biotic uptake. In aquatic systems, phosphorous is usually a limiting nutrient. However, phosphorous increases in aquatic systems may increase primary production. Increased primary production due to nutrient enrichment can impair designated uses of water. Adverse effects can include changes in water chemistry, DO levels, less recreational use, and a decline in aesthetic values.

The total nitrogen concentrations for the Clearwater and Snake rivers show a slight decline for the onset of the spring runoff to a minimum level in July, rising to maximum values in the early autumn. The late season increase may be due to a reduction in plant uptake associated with aquatic plant and algae dying back or going dormant, or due to agricultural harvesting and fertilization in the watershed. In general, total levels decrease throughout the lower Snake River, but are still higher than observed in the Columbia River. In the spring and summer, the total-N levels range from about 0.30 mg/l to 0.60 mg/l at the lower Snake River stations. In the fall, the total-N levels peak to between 0.8 and 1.1 mg/l (Figure 4.4-6). The Palouse River has the highest median nitrogen levels of 2.15 mg/l with a peak of 4.86 mg/l during the spring runoff.

According to Washington State Water Quality Standards, total phosphorous inputs above 0.02 mg/l and 0.035 mg/l are considered to be critical thresholds in terms of preventing excessive algal growth when ambient trophic conditions are considered to be in the lower and upper mesotrophic categories, respectively. Oligotrophic conditions represent high quality waters with good water clarity and low algal production, and eutrophic conditions represent high nutrient levels, excessive algal growth, and poor water clarity. Mesotrophic conditions are somewhere in the middle and typically represent moderate levels of algal production, water clarity, and light transparency.

The 1997 water quality data indicate that ortho-P levels in the lower Snake River tend to be moderately high in the spring (0.65 mg/l to 0.11 mg/l), relatively low in the summer (0.02 mg/l to 0.04 mg/l), and generally highest in the fall starting in mid-September (0.05 mg/l to 0.10 mg/l) (Figure 4.4-7). Both the Palouse and the Tucannon rivers had much higher total ortho-P levels throughout the 1997 sampling period ranging from 0.06 to 0.21 mg/l and 0.10 and 0.29 mg/l, respectively.

4.4.2.4 Other Contaminants

Little data have been collected with respect to other contaminants, especially heavy metals and other toxic substances. Recent test data for bottom sediments in the Snake River System indicate that peak levels of certain metals including copper and zinc may pose a concern related to the resuspension and sediment movement that may expected under the proposed alternatives. Pesticide residues and dioxins have also been noted as potential concerns throughout the lower Snake River because of the irrigation return flows and the industrial discharge. Table 4.4-3 displays the Washington water quality standards for many of these compounds. A recent sediment sampling in 1997 resulted in the collection of 94 sediment samples from the lower Snake River reservoirs in areas identified as having the highest percentage of fines. The results of the chemical and metal analyses are summarized below. See Appendix C, Water Quality for more details.

Organics

No chlorinated herbicides, organo-phosphorpus pesticides, or semi-volatile organic compounds were detected at any of the 94 sampling locations.

Dioxins

Dioxin was detected in two of four sediment samples from Lower Granite Reservoir. The detection occurred in the upper part of the reservoir. These concentrations are within the lower range of concentrations identified in studies of the lower Columbia River and the lower Willamette River (Corps, 1998a).

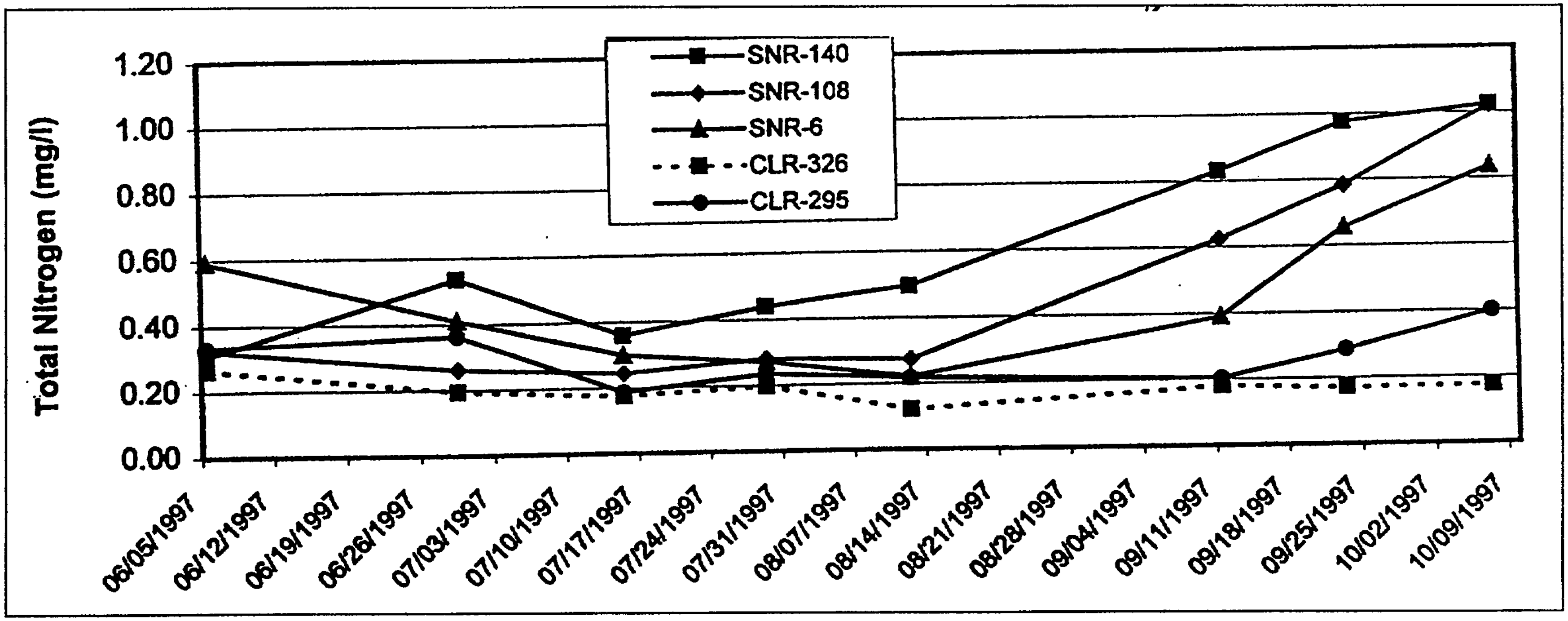


Figure 4.4-6. Total Nitrogen Level Data Measured in 1997 at Selected Water Quality Sampling Sites Throughout the Study Area
(SNR—refers to Snake River Mile)
(CLR—refers to Columbia River Mile)

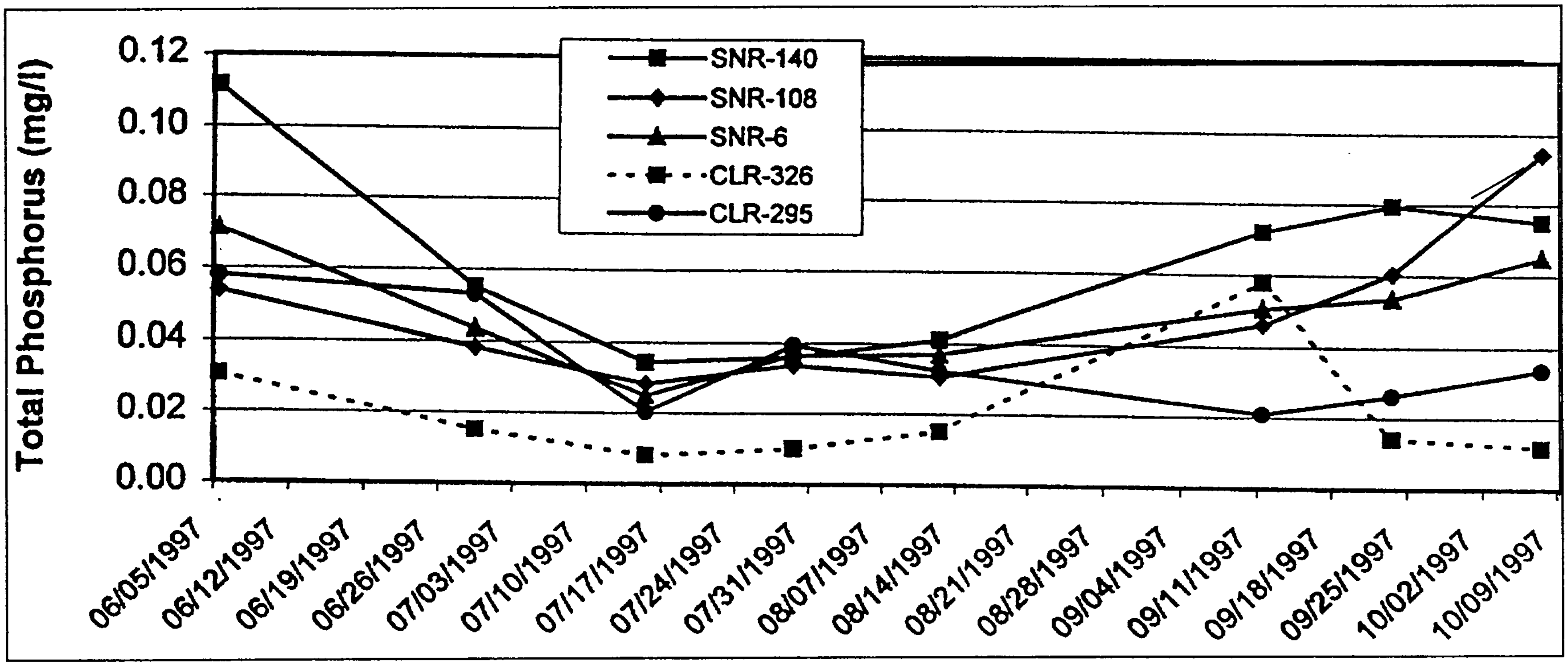


Figure 4.4-7. Total Phosphorus Data Measured in 1997 at Selected Stations Throughout the Study Area
(SNR—refers to Snake River Mile)
(CLR—refers to Columbia River Mile)

Glyphosate and AMPA

Glyphosate (N-[phosphonomethyl]glycine) is a post-emergence herbicide that is widely used for agricultural and domestic purposes. It is sold as a terrestrial and aquatic herbicide. A major metabolite of gyphosate is aminomethylphosphonic acid (AMPA).

Glyphosate and AMPA were detected in 36 percent and 16 percent, respectively, of all top layer sediment samples (94 total samples) in all of the lower Snake River reservoirs. The concentrations of glyphosate ranged from non-detected to a maximum of 68.9 parts per billion (ppb); AMPA ranged from non-detected to a maximum of 29.3 ppb. The highest individual concentrations of glyphosate and AMPA were detected in samples collected from Lake Bryan (upstream of Little Goose Dam). The highest average reach concentrations of glyphosate were found in samples collected from Lake Sacajawea (upstream of Ice Harbor Dam). The average reach concentration of glyphosate increased downstream from Lower Granite Reservoir to Lake Wallula. The highest average concentration of AMPA was found in samples collected from Lake Herbert G. West (upstream of Lower Monumental Dam) and then decreases in Lake Sacajawea.

The suspected source of glyphosate and AMPA in the sediment samples collected from the lower Snake River is runoff from surrounding uplands and through transport via stream flow. Sources for these organic compounds may include agricultural, industrial, municipal, or domestic uses within the watershed.

Organochlorine Pesticides

Several organochlorine pesticides were detected in the sediment samples collected from the lower Snake River. Total DDT (DDD, DDE, and DDT) concentrations ranged from non-detectable to 32.8 ppb. The highest mean concentration for total DDT was 11.3 ppb for Lower Granite Reservoir. The average reach concentration of total DDT decreases steadily from Lower Granite Reservoir to 5.7 ppb, as recorded in Lake Sacajawea. The proposed screening level concentration for total DDT in the Dredged Material Evaluation Framework for the Lower Columbia River Management Area is 6.9 ppb and the proposed maximum level is 69 ppb (Corps, 1998a).

The pesticides aldrin, dieldrin, endrin, heptachlor, and lindane were all detected in 5 or less of the 94 sediment samples. The detected concentrations are below the proposed screening of 10 ppb for the Lower Columbia River Management Area (Corps, 1998a).

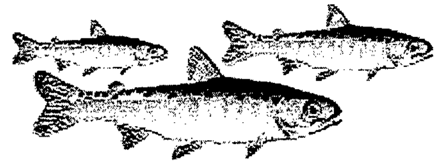
Total Petroleum Hydrocarbons

The concentrations of total petroleum hydrocarbons (TPH) ranged from non-detectable to 256 parts per million (ppm). Along the lower Snake River, the average concentration of TPH generally increases in the downstream direction with the highest average concentration found in Lake Sacajawea.

Metals

Analyses were conducted for 18 metals in each of the 94 sediment samples. The metals included: arsenic, barium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, vanadium, and zinc. All of the metals were detected in every sample except for the following: cadmium (2 samples), mercury (37 samples), silver (0 samples), and strontium (4 samples).

The high frequency of detection was attributed to the fact that all of the metals are naturally occurring. None of the metals were found to exceed screening levels. Of all the metals, only a mercury concentration of 0.38 ppm approached the proposed screening level concentration of 0.41 ppm under the Dredged Material Evaluation Framework for the Lower Columbia Management Area screening and maximum concentration levels (Corps, 1998a).



4.5 Aquatic Resources

The lower Snake River contains a wide variety of aquatic organisms. Of critical interest to this study are the various populations of anadromous and resident fish that periodically and permanently inhabit the river. This section describes the existing anadromous and resident fish resources of primarily the lower Snake River and Columbia basins.

4.5.1 Anadromous Fish

The Columbia-Snake River System supports large and varied populations of anadromous fish. Anadromous fish hatch in freshwater streams or lakes, migrate downriver to the ocean to mature, then return upstream to spawn (Figure 4.5-1). The range of anadromous fish in the Snake River are shown in Figure 4.5-2. Several species and many separate stocks of anadromous fish inhabit the Columbia and Snake rivers. These fish include spring, summer, and fall chinook salmon; coho, chum, and sockeye salmon; steelhead; sea-run cutthroat trout; American shad; white sturgeon; and Pacific lamprey. Many of these stocks are severely depleted because of changing ocean conditions, excessive harvest practices, the dams on the river system that have interfered with migration, and reduced spawning and rearing habitat quantity and quality.

The complicated nature of the life-cycle (Figure 4.5-1) and factors influencing fish at all stages ultimately has a large influence on enhancement and recovery efforts. The analysis in this document addresses primarily just a small portion of their total life-cycle, the period when they pass through the region directly influenced by the hydroelectric system. While an adult salmon or steelhead may live for typically 3 to 6 years, their occurrence within the direct influence of the hydrosystem is limited. The period includes a few days to a several weeks as most juveniles migrate to the

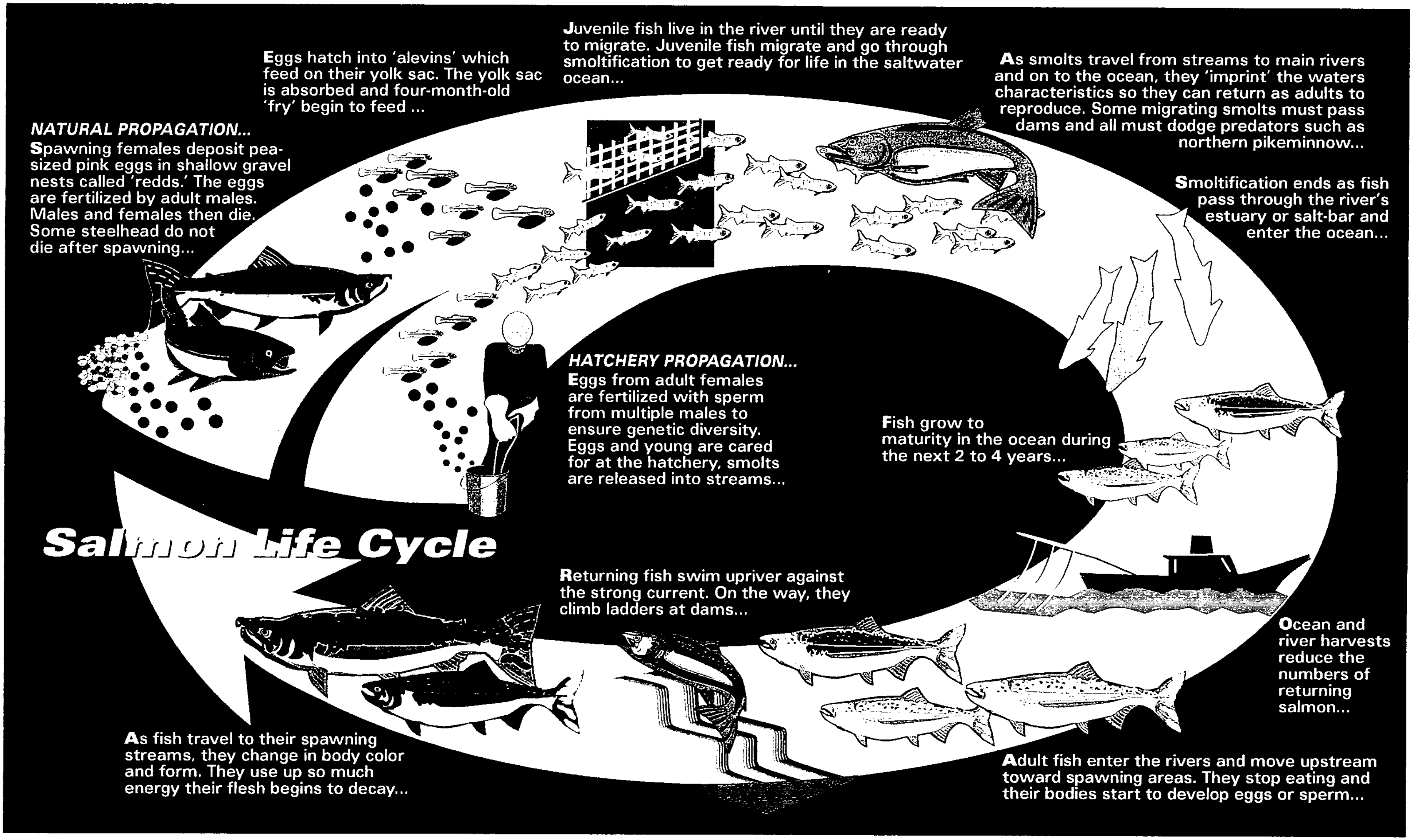
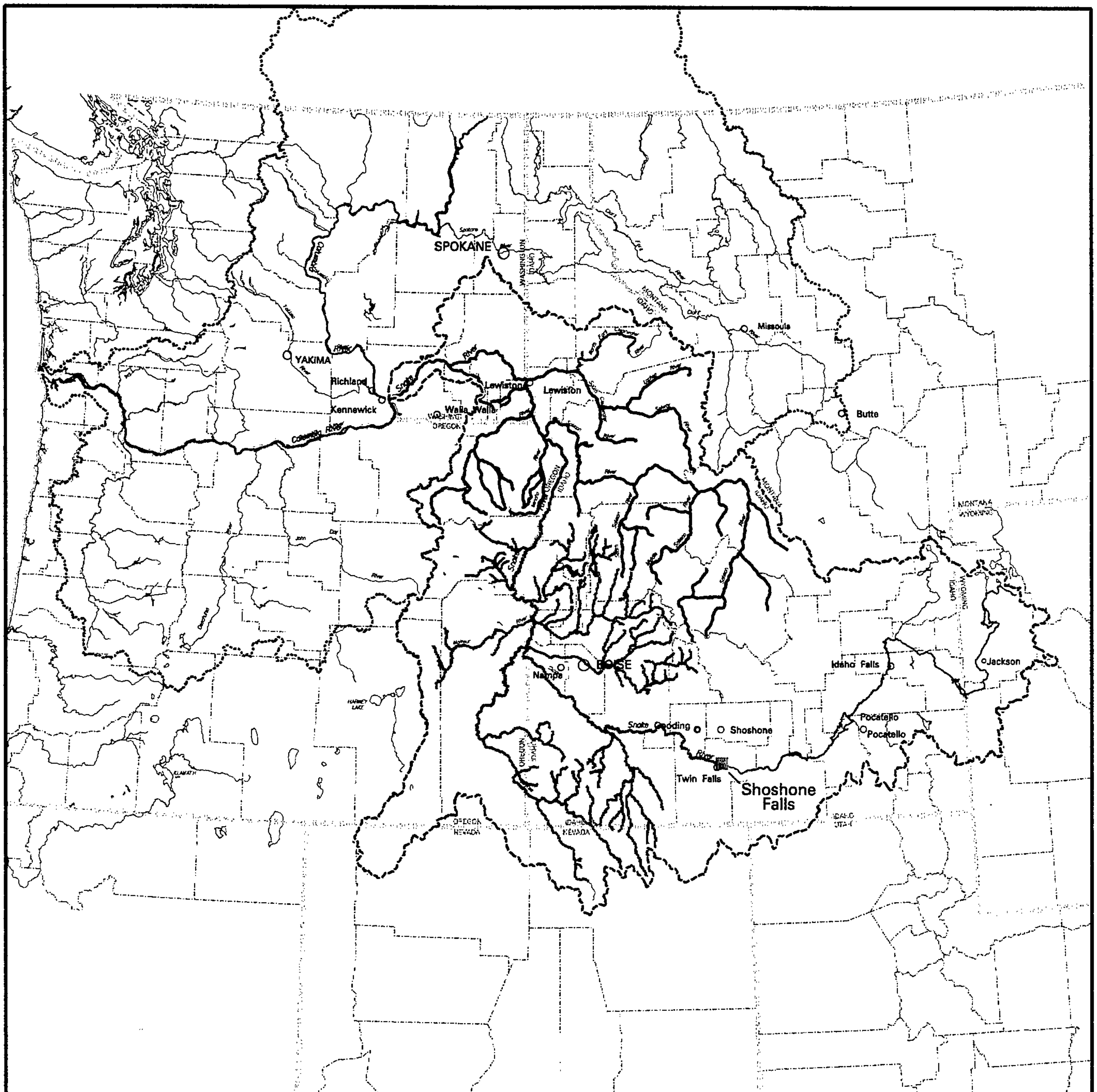


Figure 4.5-1. Salmon Life Cycle



Source: US Army Corps of Engineers Waterways Experiment Station.

SNAKE RIVER SALMON RANGE

- Present
- Historic

NATURAL HISTORICAL IMPEDIMENT
Upper Salmon Migration Limit

BOUNDARIES

- Columbia River Basin
- Snake River Basin
- State
- County

KM 100 50 0 MILES 50 100

1,000,000 ACRES

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

1 : 76,032,000

DRAFT

Lower Snake River
Juvenile Salmon Migration Feasibility Study

Figure 4.5–2.

SNAKE RIVER SALMON RANGE

1999

GIS Analysis & Graphic Assembly: Applied Technology Team (CENWW-PM-PD-E)
g:\regional\r2k\plates\lsr\jsmeis\crb\crbsm.dgn:GISFILE PLOTTED: 07 DEC 1999

ocean, and again mostly a few weeks as adults migrate upriver. The overall survival of these fish is influenced by conditions in all phases of their life-cycle from the streams where they are spawned, the downstream migration corridor, the conditions in the ocean where they reach their full growth, upstream migration corridor, and finally again the condition in their natal stream. The many- faceted nature of this life-cycle ultimately complicates efforts to enhance production of these fish. The life history and status of the various stocks, with emphasis on those originating in the Snake River, are presented in this section.

4.5.1.1 Life History

Spring Chinook Salmon

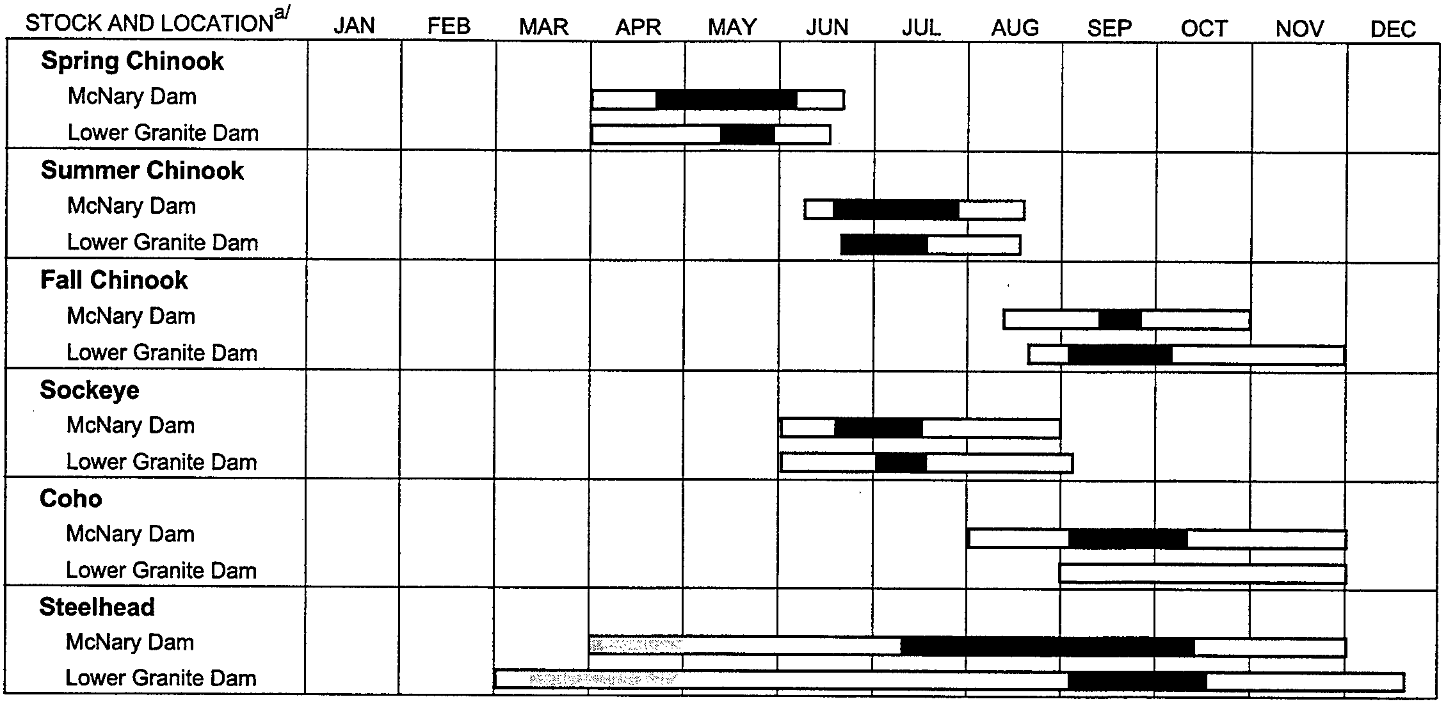
Adult spring run chinook salmon begin entering the Columbia River in February. By late June, most have passed the Corps dams on the lower Columbia and Snake rivers (Figure 4.5-3). Most spring chinook salmon migrate upstream from early April through mid-June and spawn in tributaries far upstream of project influences. Peak spawning occurs from August through October. Of the chinook stocks, spring chinook salmon typically travel the farthest up tributaries to spawn. In systems with both spring and summer chinook salmon, spring chinook salmon tend to spawn farther upstream and earlier (Matthews and Waples, 1991). However, spawning area and timing may overlap between the two stocks in some areas. This possible overlap of spawning area and timing is one of the main reasons that the National Marine Fisheries Service (NMFS) designates Snake River spring and summer chinook salmon as one stock (spring/summer) in their ESA listing (see Section 4.5.1.2, Run Status). Snake River spring and summer chinook also have the same juvenile outmigration age and timing. Within the Snake River System there are five major spawning and rearing basins for spring/summer chinook. These include three large river basins (Clearwater, Grande Ronde, and Salmon rivers) and two smaller basins (Tucannon and Imnaha rivers).

Juveniles typically rear in the rivers for more than a year, migrating downstream their second spring as yearlings from about March to June (Figure 4.5-4). The majority pass the dams during April and May. Fish then rear in the ocean mostly for 2 years before returning to the river as adults. However, a significant number spend 3 years in the ocean, some spend 4 to 5 years, and a few return after one year as "jacks" (early maturing fish) (Howell et al., 1985).

Summer Chinook Salmon

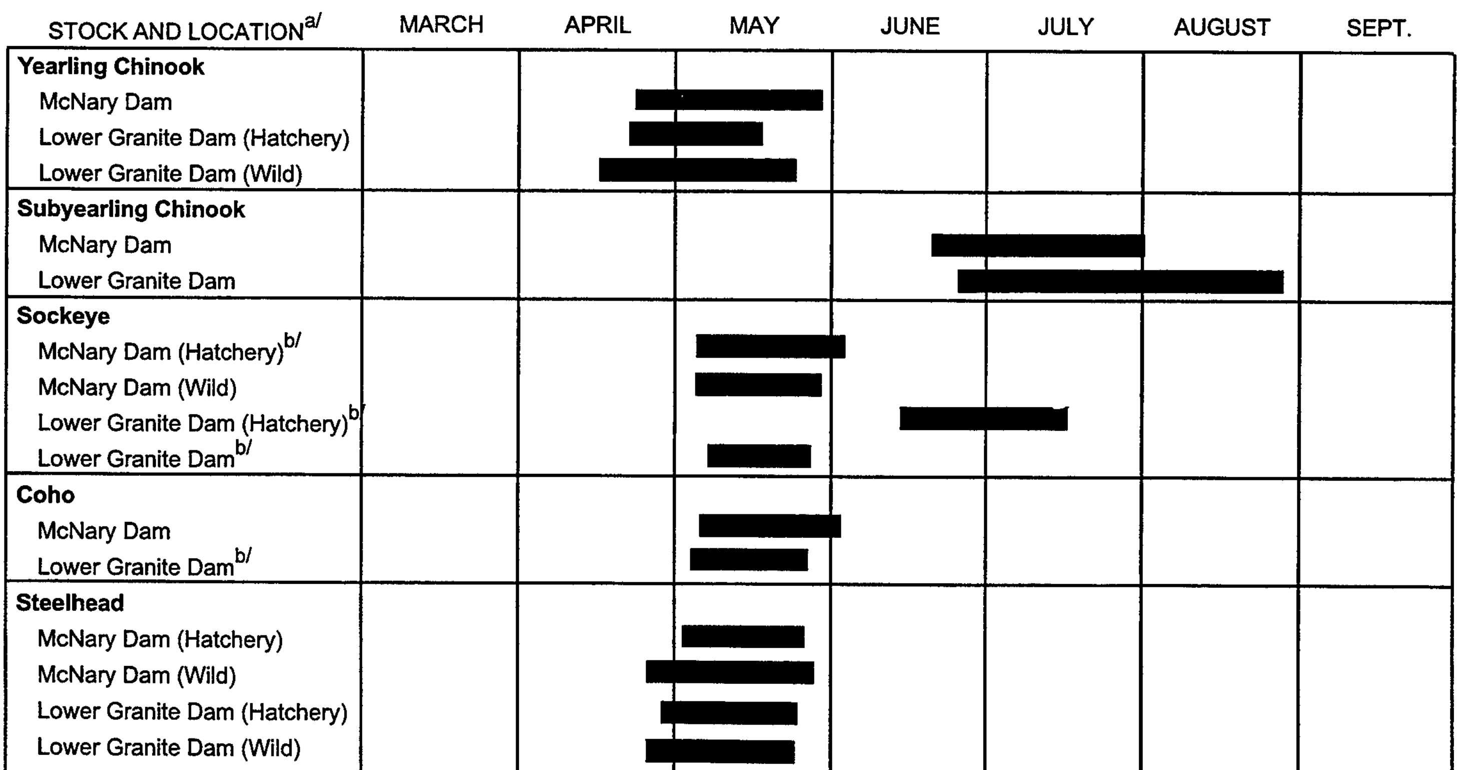
Adult summer chinook salmon begin entering the Columbia River in May and pass the mainstem dams by September (Figure 4.5-3). The majority pass from mid-June through mid-August. Summer chinook salmon generally spawn and rear upstream of the influence of the dams, although some of the upper Columbia River subyearlings rear in the lower Columbia region. Summer chinook salmon have typically dominated spawning in lower elevation streams in the upper Columbia River. In the Snake River System, spawning regions are typically in tributaries, but often downstream of spring chinook salmon. Spawning typically occurs from August

Figure 4.5-3. Adult Salmonid Main Upstream Periods



[a/] Migration period range and peak annual counts are shown as darker central region, shaded area indicates small secondary peak. (Source: Corps, 1998b)

Figure 4.5-4. Peak Periods of Downstream Migration of Salmonid Smolts



[a/] Range of 10% and 90% passage for 1991 to 1997 (FPC, 1999).
[b/] Range of 10% and 90% passage for 1998 (FPC, 1999).

through October, peaking in the Snake River System in September. Juvenile summer chinook salmon outmigrate mostly as subyearlings in the upper Columbia River and yearlings in the Snake River. The yearlings outmigrate from the Snake River during March through June, with the majority passing in April and May (Figure 4.5-4). Most Snake River adults spend 2 to 3 years in the ocean before returning, while upper Columbia River stocks may spend up to 5 years (CBFWA, 1991; Howell et al., 1985; Matthews and Waples, 1991).

Fall Chinook Salmon

Adult fall chinook salmon begin entering the Columbia River in July and pass the mainstem dams by the end of November (Figure 4.5-3). Fall chinook in the Columbia River System consists of two distinct groups: "tules" which are confined primarily to the lower Columbia River tributaries (below Bonneville Pool), and "upriver brights" which mainly spawn in the mainstem Columbia in the Hanford reach (downstream of Priest Rapids Dam) and in the Snake River System. The majority of upriver bright fall chinook salmon pass the dams from mid-August to November. The tules returning to the Bonneville pool area are primarily hatchery fish. Tules spawn typically from mid-September to mid-October, while upriver brights spawn during October and November (Dauble and Watson, 1990; Waples et al., 1991).

The current spawning area for Snake River fall chinook salmon is limited to the 103 miles of the Snake River below Hells Canyon Dam, and to parts of the lower reaches of the Clearwater, Grande Ronde, Imnaha, Tucannon, and Salmon rivers. Since 1993, there has been an increasing portion of spawning in the Grande Ronde and Clearwater rivers (Technical Appendix M, Fish and Wildlife Coordination Act Report). Additionally, incidental deep water spawning has been observed below Lower Granite, and Little Goose and Ice Harbor (Dauble et al., 1999).

Juvenile upriver bright fall chinook rear primarily in the mainstem river and reservoir reaches of the Columbia and Snake rivers. Those below Priest Rapids rear in the shallow water areas downstream, including the four lower river reservoirs. Those in the Snake River rear in the flowing water areas below Hells Canyon Dam and into the reservoirs. Juvenile fall chinook salmon predominately migrate as subyearlings, leaving in their first spring or summer of fresh water residence. Subpopulations of subyearling chinook may rear and overwinter in the lower Snake River or McNary Reservoir and finish their outmigration the following spring as yearlings (Paulsen 1999 in Marmorek et al. 1999), where the smolt-to-adult ratio (SAR) of such observed passive-induced transponder (PIT)-tagged populations overwintering and outmigrating in 1995 and 1996 returned at SARs of three times the SAR of their true sybyearling cohorts. Lower river, hatchery, and wild tules migrate from March through October; the majority pass the dams in July and August (Figure 4.5-4). Hanford reach upriver brights pass primarily during the same time period. Those from the Snake River pass the upper dam primarily in late June and July (Figure 4.5-4) with some passing as late as November (Technical Appendix M, Fish and Wildlife Coordination Act Report). However, most leave before late-July due to warming temperatures that are not suitable for chinook salmon in the Snake River.

Tule stocks typically rear in the ocean for 2 to 3 years (CBFWA, 1991). The Snake River fall chinook salmon typically return after 1 to 4 years in the ocean; most return after 3 years (Chapman et al., 1991).

Sockeye Salmon

Adult sockeye salmon begin entering the Columbia River in April and continue to pass by dams through October. The majority of passage occurs from June through early August (Figure 4.5-3). Sockeye are unique among salmonids in their requirement for lakes for juvenile rearing areas. Because of this requirement, sockeye distribution in the Columbia and Snake rivers is currently limited to primarily the Wenatchee and Okanogan river areas of the upper Columbia region and the upper Salmon River, a tributary to the Snake River. Juveniles rear in lakes in these systems for typically 1 to 2 years (Bjornn et al, 1968; Kline and Lamansky, 1997) before migrating to the ocean, typically from April into July (Figure 4.5-4). In the Snake River, some outmigration of wild juveniles occurs into November (Technical Appendix M, Fish and Wildlife Coordination Act Report). Most adults spend 2 years in the ocean before returning to spawn, although some Okanogan River fish return after 1 year (Bjornn et al., 1968; Mullan et al., 1986).

Coho Salmon

Almost all coho salmon are restricted to the Bonneville pool downstream. Snake River coho were initially eliminated in the early 1900s, later re-introduced in the 1950s, and this stock went extinct in 1986 and have recently been stocked into the Clearwater River (see Section 4.5.1.2, Run Status). The only wild run above Bonneville Dam is found in Hood River, a tributary entering the Bonneville pool (BPA et al., 1995 [Appendix C]). Coho salmon enter the Columbia from August through December. Passage over dams occurs from August through November, with the peak period in September and early October. The recent small numbers of reintroduced returns of coho salmon to the Clearwater River System from releases of hatchery fish by the Nez Perce Tribe have been passing Lower Granite primarily from September through November (Figure 4.5-3) (Technical Appendix M, Fish and Wildlife Coordination Act Report). The spawning period in lower river areas typically would be from late September into December (BPA et al., 1995). The peak spawning period for the Hood River stock is November and December (Howell et al., 1985). Juveniles rear in tributary streams and outmigrate as yearlings in the spring, typically during April and May. The current hatchery stocks being released into the Clearwater River would be expected to pass the Snake River dams from late March into April (Technical Appendix M, Fish and Wildlife Coordination Act Report), although recent counts show that most pass in May (FPC, 1999). Except for "jacks," which return after only one summer in the ocean, coho are consistent in their ocean rearing, spending only about 1.5 years in the ocean before returning to their natal stream to spawn.

Steelhead

Adult steelhead enter the Columbia River year-round as winter or summer races. Most winter race fish are restricted to the Bonneville pool downstream. Winter steelhead passing dams are considered to be those passing from November through March. The summer race is found in most areas, but is the only one present in the upriver areas. The upriver summer steelhead are divided into two groups (A-run and B-run), based on migration timing, ocean age, and adult size (62 FR 43937). A-run fish originate in production areas throughout the Columbia-Snake River System, while B-run fish are only found in the Clearwater and Salmon River drainages

(CRFMP TAC, 1997). A-run fish enter the Columbia mainly in June to early August and B-run enter from late August into October (CRFMP TAC, 1997) (Figure 4.5-3). Although most steelhead enter in the summer months, they do not spawn until the following late winter or spring period. Some summer steelhead overwinter in reservoirs before advancing upstream the next spring to spawn. All steelhead do not die following spawning, but may residualize or outmigrate as "kelts" to return to spawn a second time in following years.

Juvenile steelhead rear primarily in rivers upstream of mainstem project areas. Most steelhead migrate as smolts at age 2 or 3 years primarily from March through June, with the majority passing in April and May (Figure 4.5-4). Most adults spend 2 years in the ocean before returning, although some return after 1 year or after longer than 2 years. Typically B-run steelhead spend longer in the ocean than A-run steelhead, and they are larger when they return (Busby et al., 1996).

Chum Salmon

Although a few chum salmon do pass Bonneville Dam, they are essentially restricted in their distribution to a few small Columbia River tributaries below Bonneville Dam, including Grays Basin, Hardy Creek, and Hamilton Creek (Howell et al., 1985). Recently, some have been observed spawning in a small area of the mainstem Columbia River just downstream of Bonneville Dam. They enter the Columbia River in mid-October through November. Peak spawning typically occurs in late November into mid-December in tributary streams. Juveniles emerge from the gravel their first winter/spring and migrate almost immediately downstream to the ocean as fry stage juveniles (Salo, 1991), with peak stream abundance from mid-March to mid-May (Howell et al., 1985). Columbia River stock adults rear in the ocean primarily 3 to 4 years before returning to their natal streams to spawn.

American Shad

American shad, a member of the herring family, is a non-native fish imported from the Atlantic coast which has successfully established a population in the Columbia-Snake River System. They were first introduced to the Pacific Coast in the 1870s and 1880s in the Sacramento River. They were first observed in the Columbia River in 1877 and were later released into the Columbia River System in 1885 and 1886 (Craig and Hacker, 1940). Adults enter the Columbia River beginning in April through August. The majority of passage occurs from mid-May through July at Bonneville Dam. Abundance decreases as they move upstream but some fish do pass Lower Granite. Passage stops at Priest Rapids Dam on the upper Columbia. Shad spawn in varied areas but may prefer shallow, gently sloping areas with clean sand and gravel (BPA et al., 1995). Tailwater regions below various dams may be important spawning areas (Technical Appendix M, Fish and Wildlife Coordination Act Report). The spawning period peaks from late June to early August at Bonneville dam and upstream. Larvae and juveniles rear in the reservoirs, outmigrating in the late fall and winter (October through December) of their first year, when they are about 4 inches long. Adults spend 3 to 4 years in the ocean before returning to spawn in their natal stream (Wydoski and Whitney, 1979).

Sturgeon

White sturgeon, a member of an ancient group of fish without true bones, are the largest anadromous fish in the Western Pacific, reaching a size of up to 1,800 pounds. They may live over 80 years (Wydoski and Whitney, 1979). The stock is indigenous to the Columbia River System, and there are both anadromous and non-anadromous varieties. However, the anadromous variety from below Bonneville Dam is considered to be essentially separate from the resident populations found in the reservoirs and rivers upstream of Bonneville Dam because few anadromous fish migrate past the dams (ODFW and WDFW, 1998). This species is also relatively abundant in the Snake River above Lower Granite (BPA et al., 1995 [SOR Appendix C]). The populations within the reservoirs complete their lifecycle without ever entering the ocean, with most remaining entirely within the reservoir of their birth. The anadromous form is present in the Columbia River below Bonneville Dam the entire year, although seasonal movements occur. Fish are not likely to spawn until they are greater than 10 and 20 years of age for males and females, respectively (Scott and Crossman, 1973). Adults may spawn only once every 2 to 8 years. Spawning typically occurs from April into July in the lower Columbia River (Parsley et al., 1993). In reservoirs and below Bonneville Dam, spawning often occurs in the tailrace areas which contain suitable habitat that varies with flow quantity (Parsley and Beckman, 1994; Parsley et al., 1993). Egg develop into larvae which settle to the bottom. Young-of-the-year and juveniles are found in deep water areas of lower Columbia River reservoirs and below Bonneville Dam (Parsley et al., 1993; McCabe and Tracy, 1994).

Pacific Lamprey

The Pacific lamprey are also members of the group of fish without bones and resemble eels. As adults in the marine environment, they are parasitic on other fish. Adults enter freshwater between April and June, migrating to spawning areas by September (Close et al., 1995). Peak upstream dam passage typically occurs during July, August, and September (Corps, 1997, 1998b). Spawning typically occurs in June and July, generally in low-gradient stream sections where gravel is deposited. Spawning typically occurs in flowing water areas, although it may occur in slack water environments (Close et al., 1995). Spawning has been observed in small tributaries entering mainstem reservoirs (Wydoski and Whitney, 1979). Current distribution includes fish ascending to both the Hells Canyon and Chief Joseph dams. Although distribution within tributaries is not well known (Close et al., 1995), there are low numbers in many major tributaries above Bonneville Dam (Jackson and Kissner, 1998). After hatching, juvenile stages (ammocoetes) drift downstream and burrow into the substrate sand or mud. After residing in the substrate for 5 to 6 years, juvenile lamprey metamorphose and outmigrate to the sea, primarily from April through mid-July. Passage at dams on the Columbia River, based on juvenile collection facility capture, has been from March to June, with the majority passing dams in May and June. But most migrants may not use the passage facilities, and these facilities are not operated in late fall and winter, so estimates of migration timing may not be completely accurate (Close et al., 1995). After 20 to 40 months in the ocean, they return to spawn in the river systems (Kan, 1975).

4.5.1.2 Run Status

Before Euro-Americans settled and developed the region, annual runs of salmon and steelhead returning to the Columbia River were estimated to be 8 to 16 million fish (NPPC, 1986). During the late 1970s and early 1980s, it was estimated that total runs had decreased to about 2.5 million salmon and steelhead (including fish harvested in the ocean) (NPPC, 1986). With the increase in hatchery production, the portion of wild fish decreased from about 75 percent in the 1970s to about 25 percent by the mid- to late-1980s. While recent estimates of total runs including ocean harvest are not available, they likely have changed little from this value because harvest of many of the more abundant stocks remains high in the ocean. Since 1938, the estimate of minimum total salmon and steelhead surviving the ocean conditions and ocean harvest and returning to the river has ranged from 0.7 to 3.2 million fish (Figure 4.5-5). The values in Figure 4.5-5 are based on Bonneville Dam counts, plus estimates from lower river harvest and tributary turnoff. In 1995, the lowest historical estimate of 670,000 salmon and steelhead entered the Columbia River occurred, but estimates have increased in recent years. Only about one-quarter of all recently returning fish are wild fish (ODFW and WDFW, 1998). Many factors affect abundance of stocks that return to the Columbia River System. These include conditions in both the freshwater and marine environment. Some may be local and others more regional in their effect. For example, the large increase in returning chinook in the mid-1980s appeared to be a regional phenomenon; many west coasts stocks of chinook from California to Washington showed a large increase in returns during this year (Olsen and Richards, 1994). The causes are likely related to regional weather and ocean rearing conditions during this period.

While much of the habitat for salmon and steelhead has been lost or altered, many areas still support runs. Table 4.5-1 lists the salmon and steelhead races in streams. The overall trend for wild salmon and steelhead originating from the Columbia-Snake River System has been a decrease in numbers. NMFS has used the term "Evolutionary Significant Units" (ESUs) to define anadromous fish populations being considered for listing under the ESA (Waples, 1991). The term ESU may include portions or combinations of more commonly used definitions of stocks within or across regions and therefore may not correlate exactly with stocks discussed. This declining trend and the low numbers of returning wild fish have resulted in the listing of 12 ESUs and the currently proposed listing of one other in the Columbia-Snake River System as threatened or endangered under the Federal ESA (Table 4.5-2). The listings include four Snake River ESUs: sockeye salmon, fall chinook salmon, spring/summer chinook salmon, and steelhead. As a result of these listings, the portions of the Columbia and Snake rivers used by the listed Snake River salmon species have been designated as critical habitat under the ESA. Other anadromous fish ESUs in the Columbia-Snake River System that are listed, proposed for listing, or proposed as candidate species include: listed as endangered—the upper Columbia River steelhead and upper Columbia River spring-run chinook salmon; listed as threatened—lower Columbia River steelhead; lower Columbia River chinook salmon, and upper Willamette River chinook salmon, middle Columbia River steelhead, and upper Willamette River steelhead; and the Southwestern Washington/Columbia River

Table 4.5-1. Wild and Hatchery Races of Salmon and Steelhead in the Columbia River Basin

	Race							
	Spring Chinook	Summer Chinook	Fall Chinook	Coho	Sockeye	Chum	Winter Steelhead	Summer Steelhead
Lower Columbia River (Below Bonneville Dam)[1/]								
Lower Columbia River (Mainstem)			X	X		X	X	X
Grays River			X	X		X	X	
Elochoman River			X	X		X	X	X
Cowlitz River	X		X	X			X	X
Kalama River	X		X	X			X	X
Lewis River	X		X	X		X	X	X
Willamette River	X		X	X			X	X
Sandy River	X		X	X			X	X
Washougal River	X		X	X			X	X
Mid-Columbia (Bonneville Dam to Priest Rapids Dam)[1/]								
Mid-Columbia (Mainstem)			X	X				X
Wind River	X		X	X			X	X
Little White Salmon River	X		X	X				
White Salmon River	X		X	X			X	X
Hood River	X		X	X			X	X
Klickitat River	X		X	X			X	X
Fifteen Mile Creek							X	
Deschutes River	X	X	X	X				X
John Day River	X							X
Umatilla River	X		X	X				X
Walla Walla River	X							X
Mid-Columbia Mainstem (Hanford Reach)			X					X
Yakima River	X	X	X	X	X			X
Snake River								
Snake River (Mainstem)			X					X
Tucannon River	X							X
Clearwater River	X	X	X	X[2/]				X
Grande Ronde River	X		X					X
Imnaha River	X		X					X
Salmon River	X	X	X		X			X
Upper Columbia River (Priest Rapids Dam to Chief Joseph Dam)[1/]								
Upper Columbia (Mainstem)			X	X				X
Wenatchee River	X	X			X			X
Entiat River	X							X
Methow River	X	X						X
Okanogan River	X	X			X			X

Source: CBFWA, 1991.

1/ Definition and terminology for Columbia River reaches are those of the source.

2/ Introduced in 1995.

Table 4.5-2. Federally Listed, Proposed, or Candidate Anadromous Fish Species (Ecologically Significant Units [ESUs]) in the Columbia River Basin

Species/ESU Status/Fed. Reg. Month & Year	Major Regional Distribution[1/]			
	Snake River	Upper Columbia River (above McNary Dam)	Middle Columbia River (Between McNary and Bonneville Dams)	Lower Columbia River (Below Bonneville Dam)
Snake River Fall Chinook Salmon (T, 4/92)	X			
Snake River Spring/Summer Run Chinook Salmon (T, 4/92)	X			
Snake River Sockeye Salmon (E, 11/91)	X			
Snake River Steelhead (T, 8/97)	X			
Upper Columbia River Spring Chinook Salmon (E, 3/99)		X		
Upper Columbia River Steelhead (E, 8/97)		X		
Middle Columbia River Steelhead (T, 3/99)		X (Below Priest Rapids Dam)	X	
Southwest WA/Columbia River Coastal Cutthroat Trout (PT, 3/99)			X (Below The Dalles Dam)	X
Lower Columbia River/Southwest WA Coho Salmon (C, 7/95)			X (Below The Dalles Dam)	X
Lower Columbia River Chinook Salmon (T, 3/99)				X
Lower Columbia River Steelhead (T, 3/98)				X
Columbia River Chum Salmon (T, 3/99)				X
Upper Willamette River Chinook Salmon (T, 3/99)				X
Upper Willamette River Steelhead (T, 3/99)				X

[1/] Minor exceptions to distribution region may occur
E = Endangered, T = Threatened, P = Proposed, C = Candidate

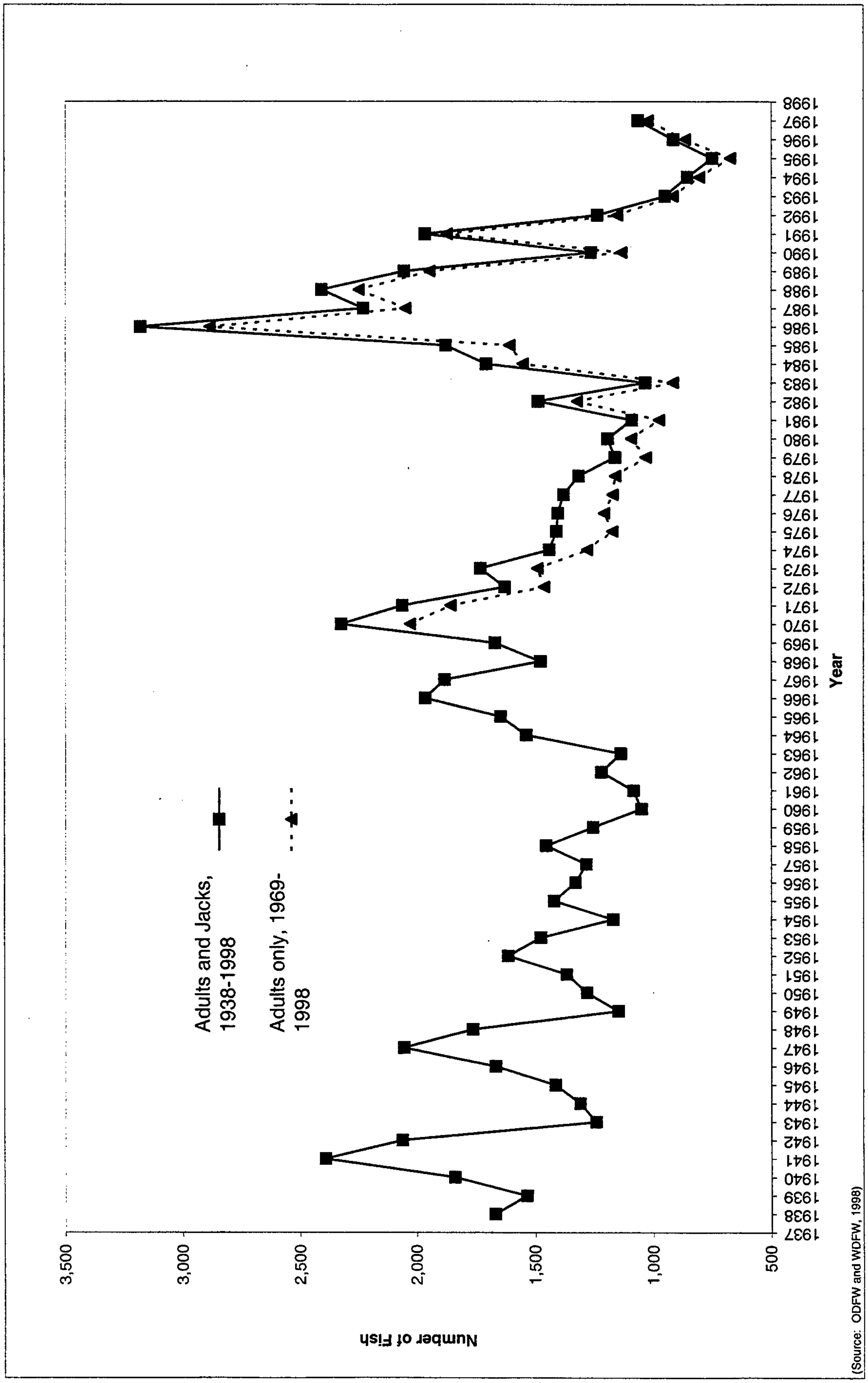


Figure 4.5-5. Minimum Numbers (in Thousands) of Salmon and Steelhead, Including Jacks, Entering the Columbia River, 1938-98

coastal cutthroat trout; candidate species—the southwest Washington/lower Columbia River coho salmon. The proposed listing of the Deschutes River fall chinook as part of the threatened Snake River fall chinook ESU has been deferred.

Snake River Spring and Summer Chinook Salmon—Prior to the arrival of Euro-Americans, the Snake River Basin produced about 1.4 million chinook salmon (NPPC, 1986). By the mid-1950s, this number was reduced by 95 percent, and another tenfold decrease has occurred in the last 30 to 40 years (Matthews and Waples, 1991).

The numbers of spring and summer chinook redds in index areas have decreased steadily from initial counts in 1957 of over 13,000 redds in all index areas (Matthews and Waples, 1991) to less than 600 in 1980. Index counts of spring and summer chinook salmon in comparable regions of Idaho and Northeast Oregon have decreased from the early 1960s to 1980. Counts have fluctuated since then with lowest counts occurring in 1995 at less than 200 total redds counted in all index areas (Figure 4.5-6) (ODFW and WDFW, 1998).

Post-1977 estimates of wild and hatchery fish over Lower Granite, including most endangered stocks of spring and summer chinook salmon, showed a high in 1978 of 31,375 wild spring and 11,600 wild summer chinook salmon. Beginning in 1978, wild fish numbers decreased dramatically with subsequent moderate fluctuations (Figures 4.5-7 and 4.5-8). Lowest values were 305 summer chinook in 1994, and 745 spring chinook in 1995 over Lower Granite. Both stocks have increased substantially from these lowest values in recent years, but returns still remain low. Hatchery fish, which are not considered part of the listed spring and summer stocks, have had large fluctuations. They had the lowest returns in 1995 with less than 400 fish from spring and summer stocks passing Lower Granite (Figures 4.5-7 and 4.5-8). These low values were followed in 1997 by the largest every recorded count of these hatchery stocks over Lower Granite. The total count of spring chinook salmon (hatchery plus wild) was also down in 1999 to 3,296 adult fish, about one-third of the 10 year average. However, jack count of spring chinook (2,507) was higher than 22 of the last 23 years. High jack counts are usually an indication of large returns in future years. The summer chinook (hatchery plus wild) was also lower in 1999, but less than spring chinook at 3,259 adult fish, about 77 percent of the 10 year average. This stock also had high jack counts (1,584) a liking indicant of much higher returns in 2000.

Snake River Fall Chinook Salmon—Fall chinook salmon in the Snake River are assumed to have made up a significant portion of all chinook salmon in the system. Between 1910 and 1967, several hundred miles of spawning area were lost because dams were built upstream from Hells Canyon. Additional spawning area was lost when dams were built on the lower Snake River. Wild fall chinook salmon declined from an estimated average of 72,000 between 1938 and 1949 to 29,000 in the 1950s (Waples et al., 1991) to about 1,000 in the mid-1970s. Wild fish generally decreased through the 1970s and 1980s to a low in 1990, when 78 fall chinook passed Lower Granite. In recent years, however, fall chinook returns have increased, except in 1998, over Lower Granite (Figure 4.5-9). In fact, the highest count on record of wild fish over Lower Granite Dam (greater than 1,600 fish), more than 60 percent higher

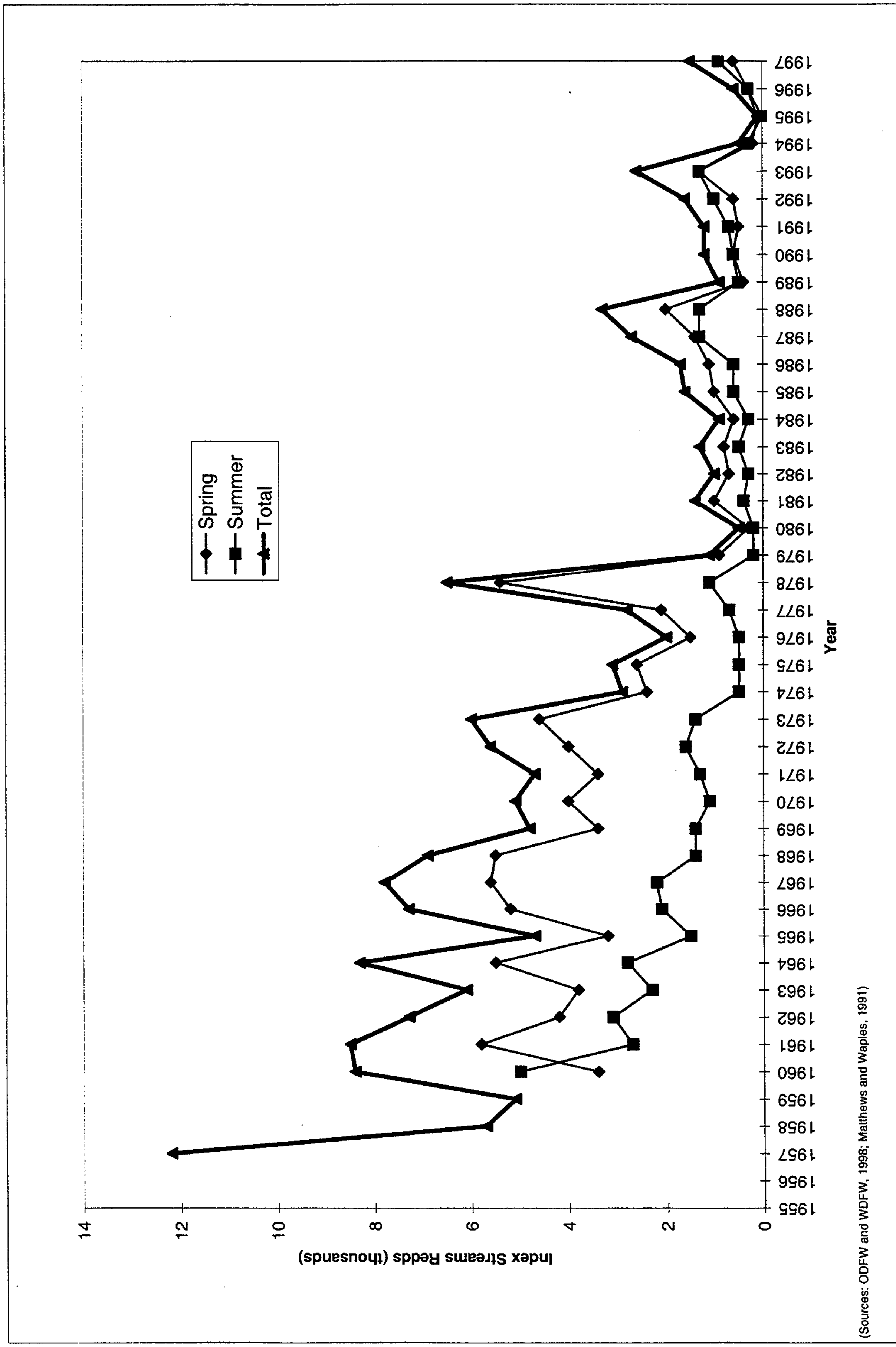
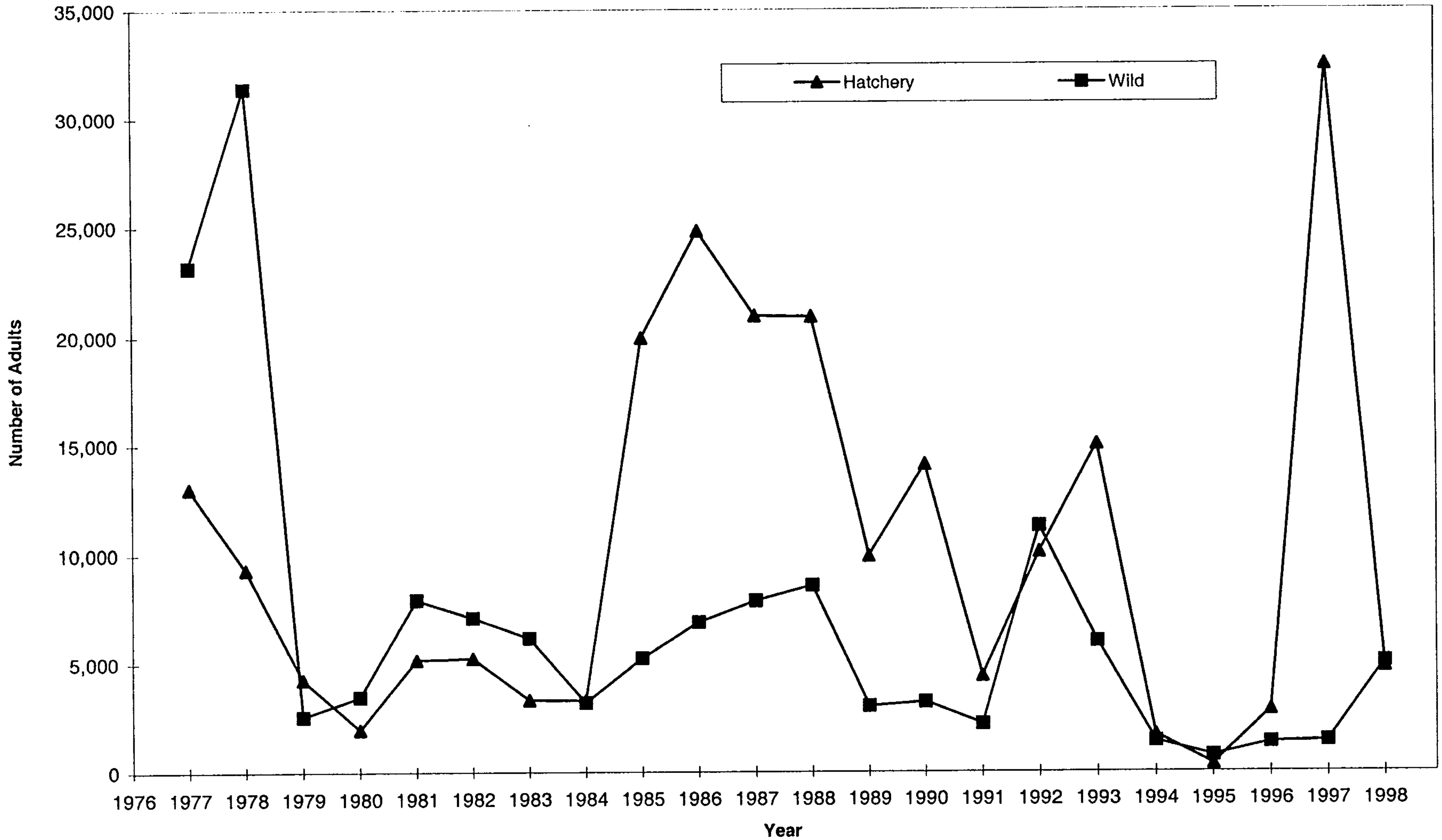
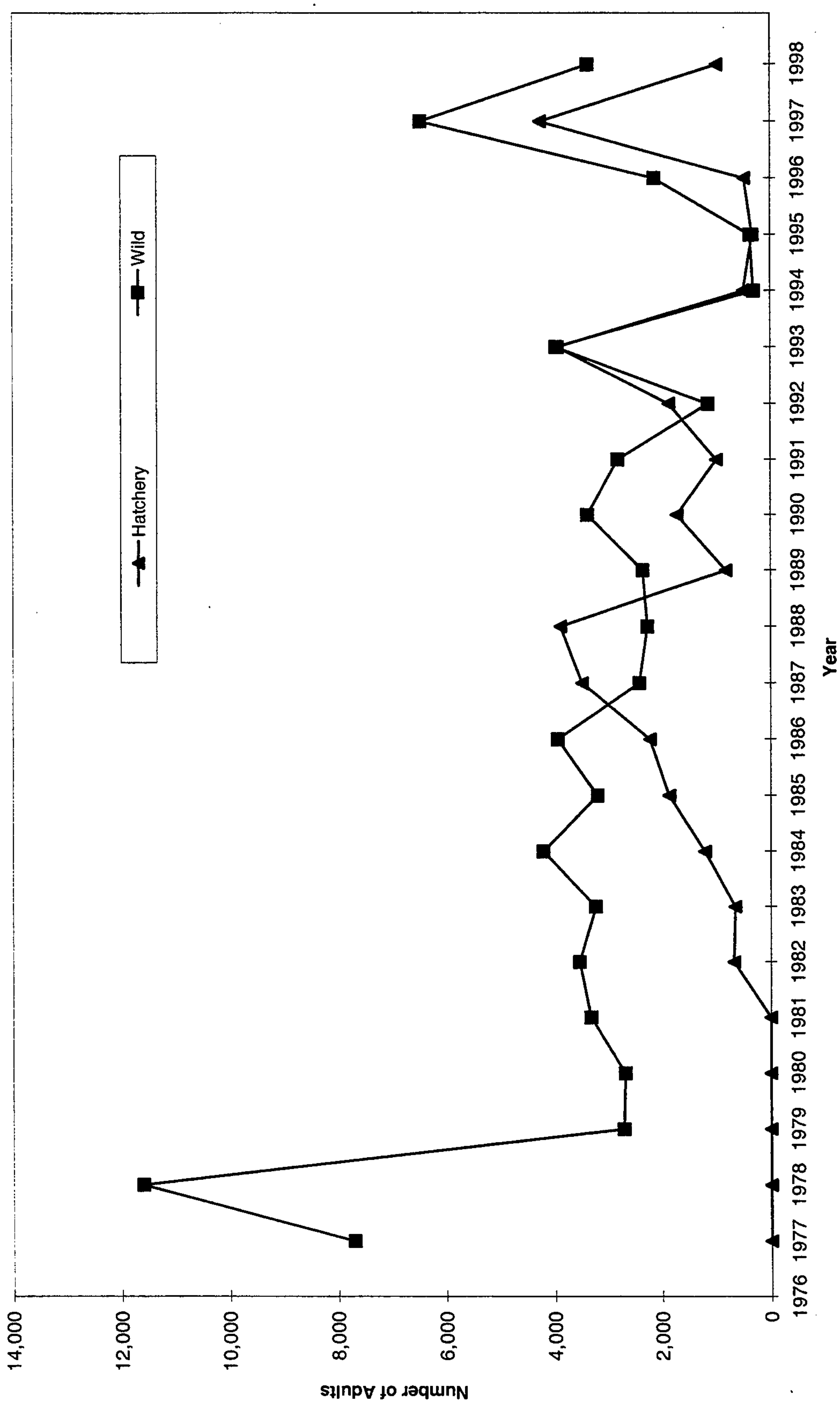


Figure 4.5-6. Index Streams Spring and Summer Chinook Redd Counts in Northeast Oregon and Idaho, 1957-1997



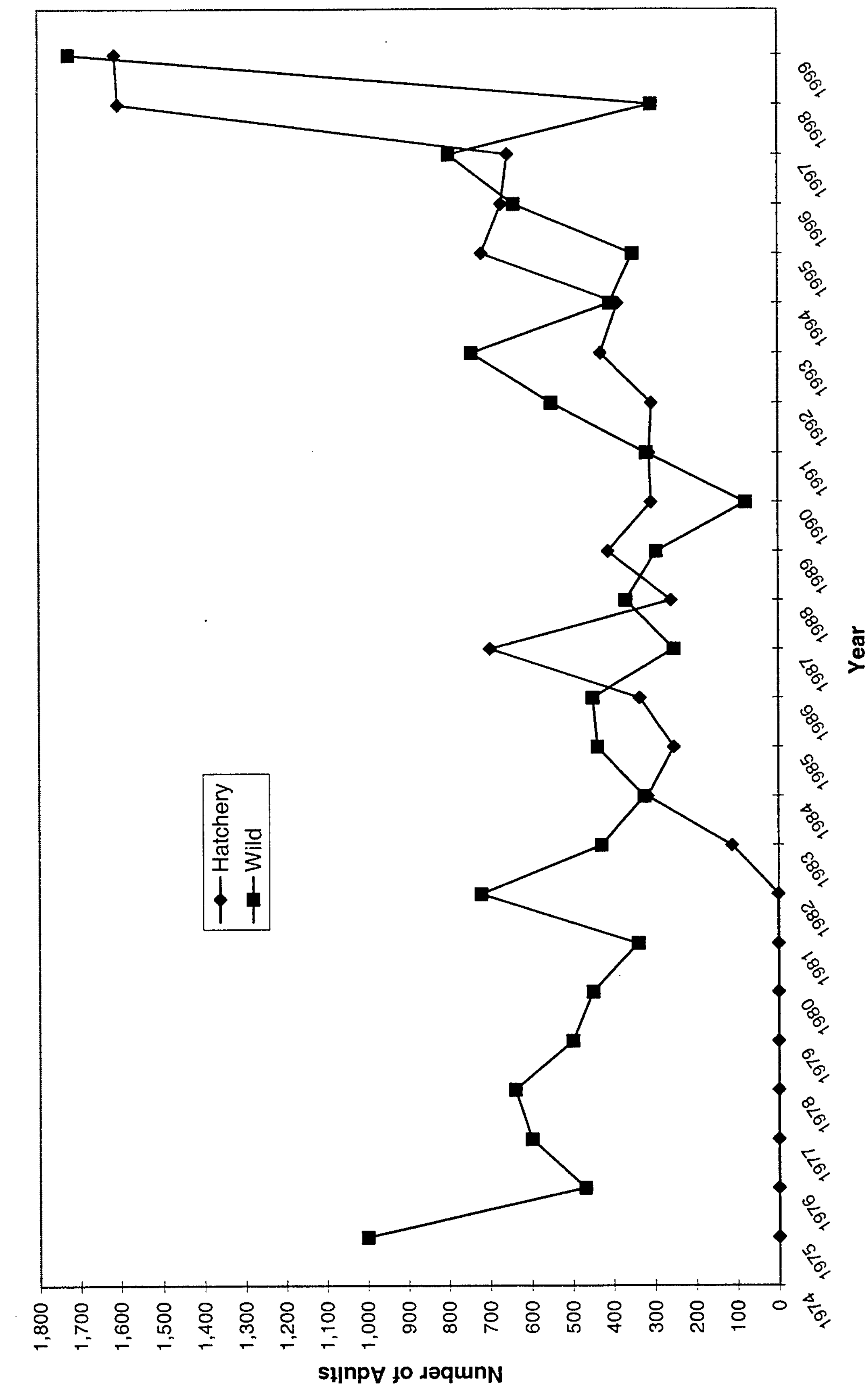
(Sources: PSC, 1991; CRFMP TAC, 1997; ODFW & WDFW, 1998; Personal Communication, Cindy LeFleur, WDFW, Vancouver, WA, 1998)

Figure 4.5-7. Estimated Wild and Hatchery Adult Spring Chinook Passing Lower Granite Dam, 1977 to 1998



(Sources: PSC, 1991; CRFMP TAC, 1997; ODFW & WDFW, 1998; Corps, 1998; Personal Communication, Cindy LeFleur, WDFW, Vancouver, WA, 1998)

Figure 4.5-8. Estimated Wild and Hatchery Adult Summer Chinook Passing Lower Granite Dam, 1977 to 1998



(Sources: PSC 1991, CRFMP TAC 1997, ODFW and WDFW 1998, Preliminary Data for 1999 from Lorna Wargo, WDFW, November 4, 1999

Figure 4.5-9. Estimated Wild and Hatchery Adult Fall Chinook Arriving at Lower Granite Dam, 1977 to 1999

than the next highest, occurred in 1999. Additionally the "jack" counts, which are often an indicator of the magnitude of follow years returns, are similar to those 1998, suggesting that the run in 2000 should be similarly very high. Hatchery fish have also increased over Lower Granite, initially because of hatchery releases from the Hagerman Hatchery, which increased hatchery adult returns in the mid-1980s. Later increases resulted from Lyons Ferry Hatchery strays on the lower Snake River, and Umatilla Hatchery strays, not of Snake River origin. Most recently, hatchery returns have increased from supplementation releases of Lyons Ferry juveniles on the Clearwater and Snake rivers upstream of Lower Granite. Unlike the other listed salmon in the Snake River System, Lyons Ferry stock is considered part of the threatened Snake River fall chinook stock.

The straying of adults from other systems, hatchery introductions that have occurred, and changes in the system lead to the question of whether the current stock is the same as the original stock that was adapted to this system (Waples et al., 1991). Based on available information, it was concluded that it was not possible to determine that they were not the original stock, even though many changes had occurred. The historical juvenile rearing habitat may have also changed. Due to the warm water, it appears that that juveniles may have migrated out of the system early, in April and May, possibly rearing farther downstream. Little information is available to indicate the rearing extent within the Snake River proper of the native stocks. It is known that historical summer temperatures were well in excess of optimal temperatures for juvenile chinook. This early outmigration out of the Snake River System may still be occurring with some fish. Passive Integrated Transponder (PIT) studies have found that some fish that left the Snake River in one year appeared the next spring passing McNary Dam. Survival of these fish was in fact much higher overall—over three times that of fish that left the previous spring (PATH Decision Analysis Report for Snake River fall chinook [Draft] May 14, 1999).

Snake River Sockeye Salmon—Historical Snake River sockeye salmon runs might have numbered 150,000 fish (NPPC, 1986). Much of the rearing habitat, primarily lakes, is no longer accessible or suitable due to nutrient depletion or displacement from state eradication programs where outcompeted by rainbow trout or other species' stocking programs. In the Snake River System, sockeye were eliminated from the Payette River System, Wallowa River System, and Salmon River System by tributary dams in the late 1800s and early 1900s. Sockeye currently present in Red Fish Lake may have originated from either residuals, or those that may have spawned below Sunbeam Dam until fish ladders allowed passage or the dam was breached in 1934. Currently, the minimum estimate of spawners that the habitat is capable of producing in the Sawtooth Valley lakes of the upper Salmon River is about 6,000 fish (CBFWA, 1991). Until recently, only Redfish Lake in the Sawtooth Valley was accessible to sockeye salmon. The recent removal of blockages has allowed access to Lake Petit and Alturus Lake.

The current restoration activities include using some of the historical lakes for outplanting captive broodstock offspring. Additionally, fertilization has been occurring in Red Fish, Pettit, and Alturas lakes to enhance production and ultimately growth and survival of hatchery reared juvenile sockeye that are being stocked into these lakes. Juveniles from the captive broodstock program have been stocked into these lakes with the goal of producing returning adults to these systems (Kline and Lamansky, 1997; Taki and Mikkelsen, 1997; Meeting Minutes, Stanley Basin

Sockeye Technical Oversight Committee, February 25, 1999 and November 18, 1998). The peak for Red Fish Lake escapement was measured at 4,361 fish in 1955 but declined after 1958 to fewer than 500 fish. The dam counts have been below 100 since 1981 (Chapman et al., 1990). From 1989 through 1998, less than 12 total fish were counted over the dam, but in 1999 at least 14 sockeye were counted (Figure 4.5-10). All but one of the fish passing in 1999 were small jack-sized fish originating from releases into upstream lakes from the captive brood stock program. Between zero and eight sockeye salmon have arrived at Redfish Lake each year since 1990 (Pavecek and Johnson, 1997; personal communication, Mr. Gislason, BPA, February 19, 1999). In 1999, a total of seven small fish, all but one originating from the captive broodstock program, arrived at Redfish Lake.

Since 1991, all fish returning to Red Fish Lake trap have been retained for a captive breeding program in an attempt to protect this stock from extinction. The 1999 returns are the first documented adult fish to have returned to any of the lakes from the captive broodstock fish releases.

Columbia River Chinook Salmon—The status of other chinook salmon stocks on the Columbia River System are varied. Upper Columbia River spring and summer chinook salmon numbers were depressed before Grand Coulee Dam was constructed in the 1930s. Summer chinook in the upper Columbia River have been relatively stable over the last 30 years. However, this stock and upper Columbia fall chinook were considered for ESA listing. NMFS issued a determination on September 23, 1994 that this stock did not warrant listing (59 FR 194) and later indicated that this and the upriver fall chinook (considered by NMFS as one ESU) are not warranted for listing (63 FR 45).

Spring chinook redd counts in upper Columbia River tributaries have changed little in recent times. But salmon counts over Priest Rapids Dam have grown from the 1960s to the 1980s, primarily because of increased hatchery production (ODFW, 1991). The large extent of hatchery influence on this stock was one of the reasons NMFS proposed the listing of the upper Columbia River spring chinook as endangered (64 FR 56). Counts of jack spring and summer chinook salmon at Bonneville Dam (which includes hatchery and wild chinook for all regions upstream) was near record levels in 1999. High jack returns typically indicate high returns the following year with the projected total run of spring and summer chinook over Bonneville Dam of about 200,000 fish for 2000, which is more than double the last 10 year average (*NW Fishletter* June 2, 1999). These fish would include members of the Columbia and Snake River stocks. Priest Rapids Dam spring chinook jack counts in 1999 were also high, about 5 times the 10 year average, suggesting stocks specifically upstream of the Snake River will be increasing in 2000. However, because the counts include both hatchery and wild fish, specific increasing projections for wild fish returns is unclear.

Upriver bright wild fall chinook, a late-spawning subspecies, have increased in the last decade. The highest return of 420,600 upriver bright fall chinook occurred in 1987, but this number fell to 81,000 in 1992. It has increased since, however, with returns over 100,000 each year (ODFW and WDFW, 1998). While most of these fish are wild, some are products of hatcheries, and their numbers have followed similar trends.

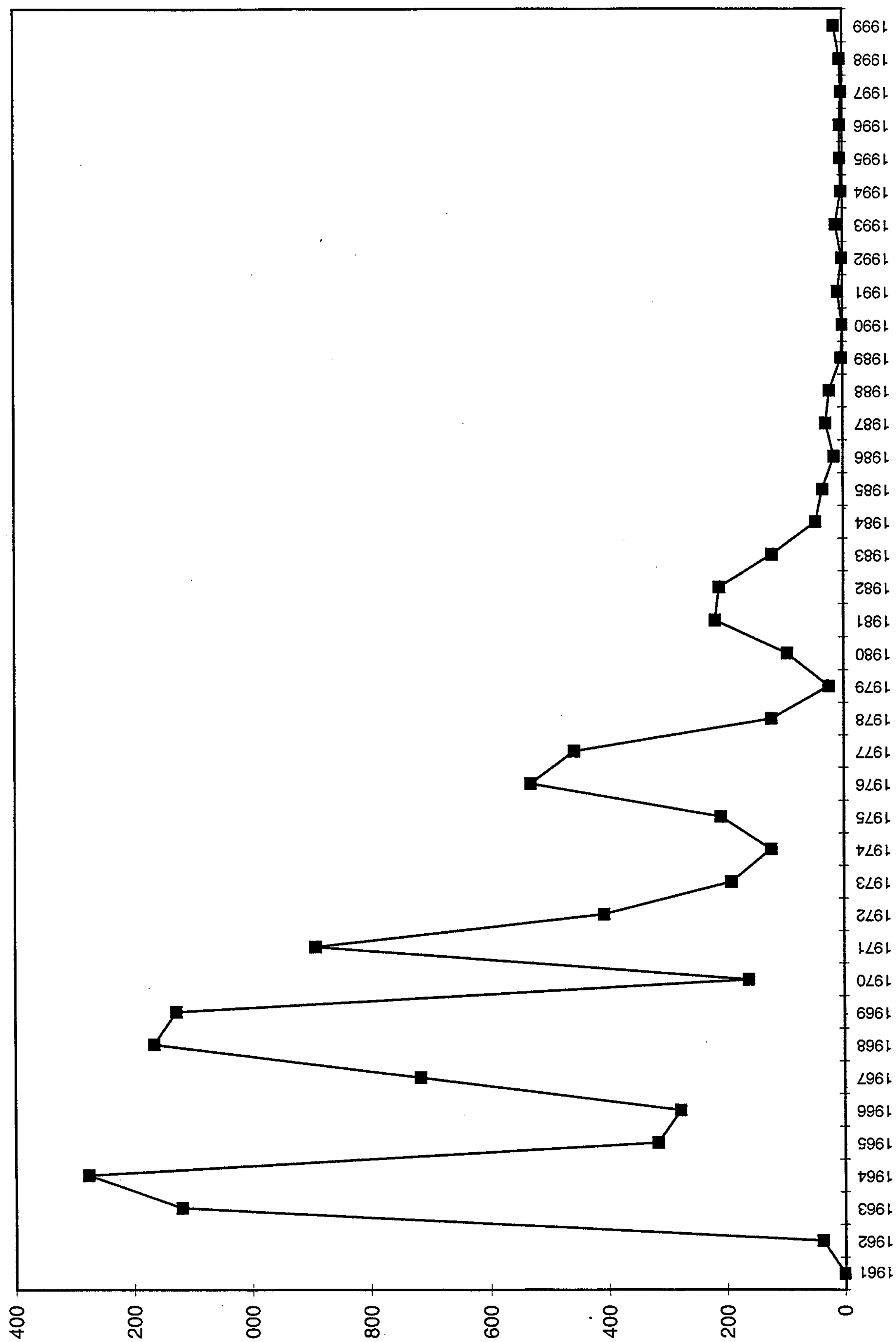


Figure 4.5-10. Estimated Wild Sockeye passing the Uppermost Dam on the Snake River (Lower Granite Dam after 1974), 1962 to 1999 (May Include Kokanee Prior to 1992)

The middle Columbia River spring chinook (which includes stream type chinook in major tributaries from the Yakima River downstream to the Deschutes River) have had recent low returns in some areas but overall have had generally long-term increasing trends. For these reasons, NMFS has determined this ESU does not warrant listing (63 FR 45).

The lower Columbia River chinook salmon is widely scattered with only a few large stocks (e.g., the Lewis). These fish have been adversely affected by many activities including land use practices, high ocean harvest rates, extensive hatchery planting, and barrier dams. The widely scattered characteristics of the subpopulations contribute to future risks for this stock and NMFS has listed it as threatened (64 FR 56).

Coho Salmon—While coho salmon were historically widely distributed in the Columbia River Basin, extending into the upper Columbia and Snake rivers, in recent times they have been primarily restricted to below Bonneville Dam, except for fish originating from hatchery releases. In the Snake River Basin, the native Wallowa River coho were wiped out in the early 1900s, and reintroduced by the Oregon Fish Commission in the 1950s (the Wallowa River is a tributary to the Grande Ronde River). The progeny of the reintroduction, not native Wallowa River coho, became extinct in 1986. As late as 1968, up to 6,000 coho returned to the Snake River. Most of these fish originated in the Grande Ronde River, a tributary to the Snake River. Recently, the Nez Pierce Tribe has been releasing coho salmon into the Clearwater River System. The result has been returns above Lower Granite in 1997, 1998, and 1999 of 92, 5, and 114 adult fish, respectively.

Historically about 120,000 to 166,500 coho were in the middle and upper Columbia River (Mullan, 1984). Nehlsen et al. (1991) considered all coho stocks above Bonneville Dam as extinct (except the Hood River, a tributary that empties into the reservoir behind Bonneville Dam).

The last recorded estimate of the Hood River run was only 100 to 300 fish in 1963 to 1971 (CBFWA, 1991). Below Bonneville Dam hatchery releases, outplanting and stock transfer has been extensive (60 FR 142). However, some native stocks may still exist in some streams such as the Clackamas (a lower river tributary to the Willamette River). NMFS considers lower Columbia stocks to be part of the same group as southwest Washington stocks and has designated this ESU as a Federal candidate species.

Currently, less than 10 percent of returning Columbia River coho salmon are considered wild. The 1991 return of 1.0 million coho was the second largest return since 1970 (ODFW and WDFW, 1998); however, Columbia River returns followed the same trends as other regional coho stocks, with sharp decreases in returns in 1995. Only 88,900 fish returned, the lowest number since 1960 (ODFW and WDFW, 1998). Returns, however, have been increasing since 1995.

Sockeye Salmon—Other Columbia River anadromous stocks have varied in their overall health. From 1938 to 1959, total sockeye salmon runs over Bonneville Dam ranged from a low of 10,900 in 1945 to a high of 335,300 in 1947; runs were stable in the 1950s. These figures include runs from the Deschutes, Yakima, Wenatchee, and Okanogan rivers, in addition to the Snake River sockeye. Since 1960, runs over

Priest Rapids Dam have decreased and varied widely, ranging from 8,700 to 170,100 (ODFW and WDFW, 1998). NMFS does not consider the upper Columbia River sockeye warranted for listing.

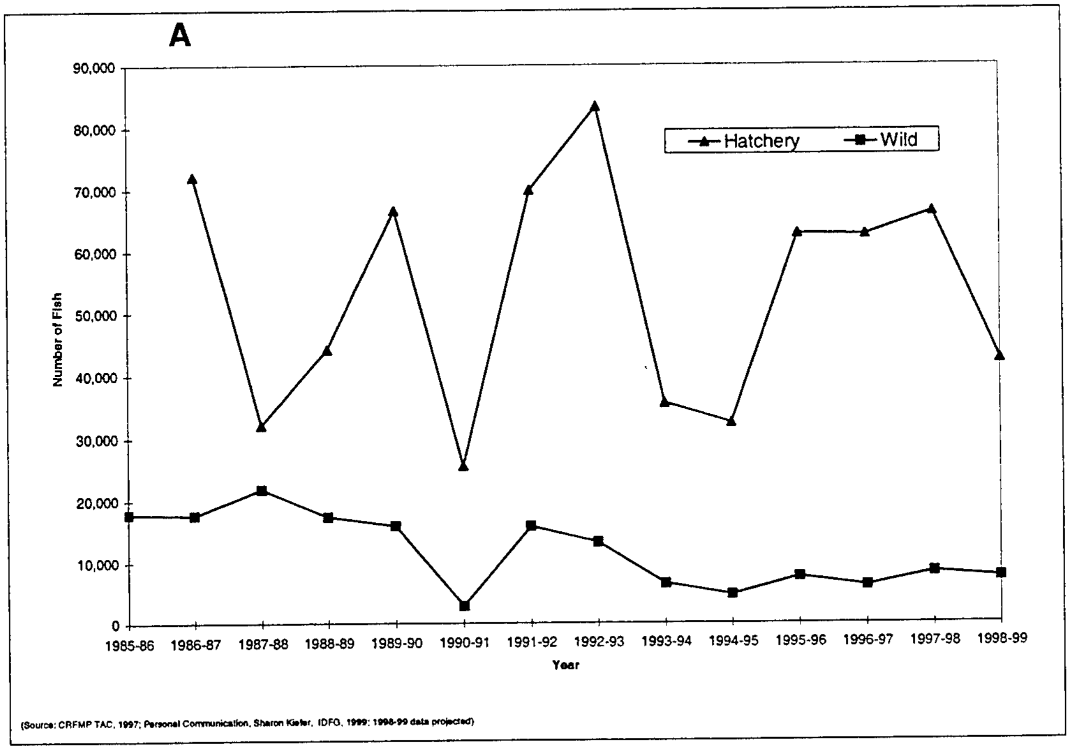
Chum Salmon—Columbia River chum salmon at one time contributed over 500,000 fish to the harvest in the Columbia River. Currently there a likely a few thousand up to 10,000 chum spawning annually, nearly all in the lower Columbia River. A minimal run estimate in 1997 was 1,600 (ODFW and WDFW, 1998). While stock abundance has remained fairly constant since the mid-1950s, NMFS considers the chum salmon to be at a significant risk of extinction and has listed it as threatened (64 FR 57).

Steelhead—One estimate of pre-European settlement steelhead run to the whole Columbia River Basin was about two million fish (NPPC, 1986). A large portion of these fish originated in the Snake River Basin. The winter steelhead, which are mostly located below Bonneville Dam, have had a generally decreasing trend for at least the last decade, including both hatchery and wild fish. Index counts have ranged from about 11,000 to 169,000 from 1953 through 1997, with lowest counts in the most recent year (1996-97) (ODFW and WDFW, 1998). Lower river summer steelhead have also been decreasing in numbers (63 FR 53). The continued decrease in abundance of these stocks among other factors has resulted in NMFS listing the lower Columbia River steelhead ESU as threatened (63 FR 53).

The run of 423,000 upper Columbia and Snake river summer steelhead in 1940 was the largest recorded since Bonneville Dam was built. Nearly all were of wild origin. Summer steelhead above Bonneville Dam are characterized as A-run or B-run. In later years, the hatchery portion of the runs became a much larger component of the total run. Total abundance of these two groups of summer steelhead, including hatchery fish, remained high until the 1950s. They declined in the late 1970s to between 84,000 and 195,000 fish.

By the late 1980s, steelhead numbers increased to between 285,000 to 384,000 fish. The total number decreased by 1990 and has fluctuated between 165,000 and 324,000 since then (ODFW and WDFW, 1998). The increase in the late 1980s appears to reflect primarily hatchery fish since wild summer steelhead A-run and B-run counts above Bonneville Dam have not improved. The trend of generally low wild runs of A-run and B-run summer steelhead is shown in Figure 4.5-11 for the Snake River summer steelhead.

Since 1993 to 1994 total A-run and B-run wild steelhead counts have ranged from 4,700 to 8,400 fish over Lower Granite Dam. The B-run portion has been especially low, with counts of less than 1,000 fish for 3 years during this period. The hatchery component of these two groups has fluctuated without definite trends since counts began (1985 to 1986) (Figure 4.5-11). NMFS listed this Snake River Basin steelhead ESU as threatened because of the recent declining numbers of wild fish and the high portion of hatchery fish (over 80 percent of all steelhead passing over Lower Granite). NMFS determined there was a demographic and genetic risk to the small population because few natural steelhead are spread over a wide geographic area (62 FR 159). Other summer steelhead passing over Bonneville Dam are parts of two other ESUs, the middle Columbia River steelhead and the upper Columbia River steelhead. Both of these ESUs are also considered in decline and are listed as



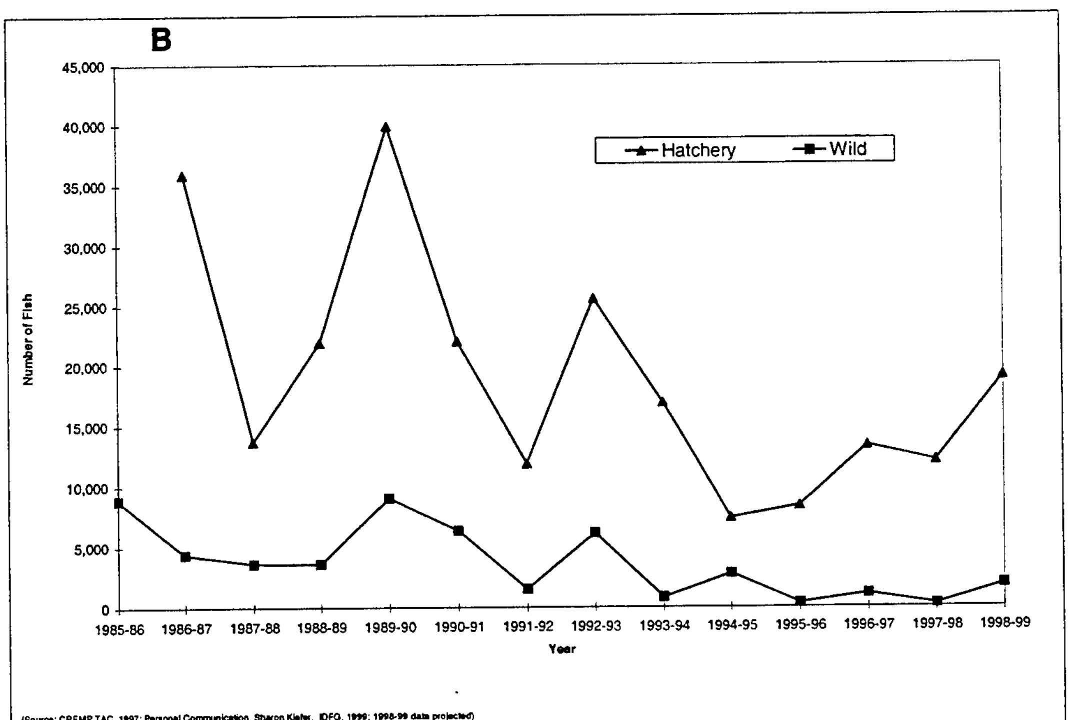


Figure 4.5-11. Estimated Wild and Hatchery A-Run (A) B-Run (B) Summer Steelhead Passing Lower Granite Dam, 1985-86 to 1998-99

endangered (upper Columbia River steelhead) (64 FR 57) and threatened (middle Columbia River steelhead) (64 FR 57).

Other Anadromous Fish—The numbers of other anadromous stocks on the Columbia River show varying trends. Shad populations have been very high in the last decade. Nine of the 10 highest ever recorded runs occurred in the last 10 years, all over 2 million fish. A peak of 4 million shad entered the Columbia River and 3 million passed over Bonneville Dam in 1990 (ODFW and WDFW, 1998).

White sturgeon in the lower Columbia River, below Bonneville Dam, are considered to be on the rebound after overharvest in the mid-1980s (ODFW and WDFW, 1998). The relatively non-migratory sturgeon populations in the Columbia River pools are considered depressed and have suffered relatively low productivity and high mortality from harvest. Pacific lamprey are also considered to be on the decline in the Columbia-Snake River System (CRFMP TAC, 1997; Close et al., 1995).

4.5.1.3 Lyons Ferry Hatchery

While hatcheries are numerous in the Columbia-Snake River System, the only hatchery that could be directly affected by any of the alternatives is the Lyons Ferry Hatchery. This hatchery is located on the north shore of the Snake River Lower Monumental Pool downstream from the mouth of the Palouse River. It is the only facility on the Snake River that currently directly collects and raises Snake River fall chinook salmon. These fish are considered part of the Snake River fall chinook ESU listed under the ESA. This is the only hatchery facility in the Snake River that has its main stock as a designated portion of a listed ESU (Snake River fall chinook). This collection and rearing of a listed ESU (other than the captive brood stock programs) is unique among hatcheries of the Columbia-Snake River System.

Lyons Ferry Hatchery also raises steelhead and spring chinook which are reared, but are not collected or released directly from this facility. Most of the fall chinook salmon brood stock are collected at Ice Harbor or from direct adult returns to the hatchery. Some also are collected at Lower Granite.

4.5.2 Resident Fish and Aquatic Community

Resident fish are freshwater fish that live and migrate within rivers, streams, and lakes. Resident fish existed in all parts of the Columbia and Snake river basins before the dams were built. They mixed with anadromous fish in stream reaches accessible to the latter, and were the only fish present in areas above barriers to anadromous fish passage. There are both native and non-native (introduced) resident fish in the Snake River Basin. While fish are the most visible and familiar element of the aquatic community, they depend on the health of other ecological components. Aquatic plants, planktonic (small drifting) organisms, and benthic (bottom-dwelling) organisms are three other key elements of the aquatic community.

4.5.2.1 Species Composition

Fish species in the reservoirs of the lower Snake River include a mixture of native riverine and introduced species that typically are associated with lake-like conditions (Bennett et al., 1983; Bennett and Shrier, 1986; Hjort et al., 1981; Mullan et al., 1986). Lower Snake River reservoirs are typically warm during the summer and either do not vertically stratify or only have weak gradation of temperature difference.

They have a relatively long (roughly 15 to 25 years) history of sedimentation; therefore, finer substrates prevail. The fine substrates, warmer temperatures, and associated lower dissolved oxygen levels tend to favor warm- and cool-water species (Bennett et al., 1983). Warm-, cool-, and cold-water species have preferences for summer water temperatures that are approximately greater than 75°F, between 65°F and 75°F, and less than 65°F, respectively (Holton, 1990).

Cold-water resident species such as trout and mountain whitefish that were once common in the Snake River have declined since the construction of the dams. Species composition has changed because spawning migrations have been blocked and habitats modified (Mullan et al., 1986). The food web has also changed since the construction of the dams, decreasing the availability of emerging aquatic insects and snails, while increasing the availability of crayfish and zooplankton. In the lower Columbia River, a shift in prey organisms may have contributed to the decline of cold-water resident species (Sherwood et al., 1990). During average and high flow years, mid-summer water temperatures are typically in the mid 60s°F. In contrast, during low flow years requiring flow augmentation for juvenile salmon passage, mid-summer water temperatures are in the upper 50s°F to low 60s°F. Regardless of flow year, peak water temperatures are usually in the upper 60s°F to low 70s°F.

The diversity of fish species is substantially higher than historical conditions. Thirty-three species of resident fishes have been observed to inhabit the lower Snake River reservoirs (Table 4.5-3). About half of these are introduced species. Native fishes include white sturgeon, trout and salmon, minnows, suckers, and sculpins. The largest group of introduced fish are in the sunfish family (Centrachidae). Eight members have been introduced including largemouth bass, smallmouth bass, pumpkinseed, bluegill, black crappie, white crappie, green sunfish, and warmouth.

Numerous catfish species are also common in the Snake River reservoirs. They include channel catfish, flathead catfish, brown bullhead, yellow bullhead, and

Table 4.5-3. List of Resident Fish Species Present in Lower Snake River Reservoirs

Family	Common Name	Scientific Name	Native or Introduced	Habitat Guild[1/]
		Cold-water Fishes		
Salmonidae	Rainbow trout	*Oncorhynchus mykiss*	N	HP/R
	Kokanee	*O. nerka*	N	
	Brown trout	*Salmo trutta*	I	HP/R
	Bull trout	*Salvelinus confluentus*	N	
	Mountain whitefish	*Prosopium williamsoni*	N	MP/LP-S
Cyprinidae	Northern Pikeminnow (Northern squawfish)	*Ptychocheilus oregonensis*	N	MP/LP-S (juv) MP/LP-D (ad)
	Speckled dace	*Rhinichthys osculus*	N	HP/R
	Longnose dace	*R. cataractae*	N	Rif/Rap
	Redside shiner	*Richardsonius balteatus*	N	MP/LP-S
	Peamouth	*Mylocheilus caurinus*	N	MP/LP-S
	Chiselmouth	*Acrocheilus alutaceus*	N	HP/R
Cottidae	Prickly sculpin	*Cottus asper*	N	Rif/Rap HP/R
	Piute sculpin	*C. beldingi*	N	Rif/Rap HP/R
	Mottled sculpin	*C. bairdi*	N	Rif/Rap HP/R
Catostomidae	Largescale sucker	*Catostomus macrocheilus*	N	HP/R Rif/Rap (ad)
	Bridgelip sucker	*C. columbianus*	N	HP/R
Acipenseridae	White sturgeon	*Acipenser transmontanus*	N	MP/LP-D
Percopsidae	Sand roller	*Percopsis transmontana*	N	MP/LP-D
		Cool-water Fishes		
Percidae	Yellow perch	*Perca flavescens*	I	S/B
	Walleye	*Stizostedion vitreum*	I	
Centrarchidae	Smallmouth bass	*Micropterus dolomieui*	I	MP/LP-S S/B (juv) MP/LP-D (ad) HP/R (ad)
		Warm-water Fishes		
Centrarchidae	Bluegill	*Lepomis macrochirus*	I	S/B
	Pumpkinseed	*L. gibbosus*	I	S/B
	Warmouth	*L. gulosis*	I	S/B
	Green sunfish	*L. cyanellus*	I	S/B
	Largemouth bass	*Micropterus salmoides*	I	S/B
	White crappie	*Pomoxis annularis*	I	S/B
	Black crappie	*P. nigromaculatus*	I	S/B
Ictaluridae	Channel catfish	*Ictalurus punctatus*	I	MP/LP-D
	Brown bullhead	*I. nebulosus*	I	S/B
	Yellow bullhead	*I. natalis*	I	S/B
	Black bullhead	*I. melas*	I	S/B
	Flathead catfish	*Pylodictis olivaris*	I	MP/LP-D
	Tadpole madtom	*Noturus gyrinus*	I	S/B
Cyprinidae	Common carp	*Cyprinus carpio*	I	S/B

Source: Technical Appendix B, Resident Fish
[1/]Habitat Guilds:
Rif/Rap: Riffle/Rapids, Velocity > 2.0 ft/sec
HP/R: Head of pool/run, Depth < 10 ft, Velocity = 0.5 – 2.0 ft/sec
MP/LP-S: Mid-pool/lower-pool, Shallow, Depth < 10 ft, Velocity < 0.5 ft/sec
MP/LP-D: Mid-pool/lower-pool, Deep, Depth = 10 – 35 ft, Velocity < 0.5 ft/sec
S/B: Slough/backwater, All depths, Velocity < 0.5 ft/sec

tadpole madtom. Most of these fish have been intentionally introduced as sportfish or unintentionally introduced as baitfish.

There is little difference in the species composition of the four lower Snake River reservoirs (Bennett et al., 1983; Bennett and Shrier, 1986; Bennett et al., 1988). Native species found in high abundance in all reservoirs include suckers (largescale and bridgelip), northern pikeminnow (formerly called northern squawfish), and redside shiner. The introduced species found in high abundance include smallmouth bass, white crappie, yellow perch, and channel catfish. Although smallmouth bass are abundant in the reservoirs relative to the entire suite of introduced species, they are found at low absolute densities compared to other locations within their range (Technical Appendix B, Resident Fish), suggesting that conditions are suboptimal. Species in the sunfish family, the crappies, and largemouth bass can generally be found in the backwaters of all reservoirs. Minor variations in species composition are related to variations in the availability of backwater habitats and flowing waters in the various reservoirs. Numerically, native species continue to dominate the composition of fish fauna, primarily due to the abundance of suckers, northern pikeminnow, and redside shiner. However, as mentioned earlier, the native resident fish species considered commercially and recreationally important (trout and sturgeon) account for a relatively minor portion of the fish fauna. The distribution of bull trout is discussed in Section 4.5.2.4, Resident Fish Species Listed Under ESA.

In addition to the species mentioned above, walleye have been captured in the Snake River below Ice Harbor and within the mid- and lower Columbia River (Zimmerman and Parker, 1995). Although adult walleye have not been captured during resident fish surveys within any of the lower Snake River reservoirs, at least six walleye have been observed at juvenile facility separators at Lower Monumental and Little Goose (Technical Appendix B, Resident Fish).

4.5.2.2 Habitat Use

The physical characteristics of the reservoirs are fundamental to the types of habitat available to fish. In many respects, the four reservoirs have physical characteristics that are not substantially different from each other (Table 4.5-4). The four reservoirs impound nearly 137 miles of the lower 156 miles of the lower Snake River. Little Goose is the largest of the four with a surface area of 10,825 acres and mean depth of 56.4 feet at the normal pool elevation. Lower Monumental is the smallest of the four and about two-thirds the size of Little Goose. Ice Harbor is relatively shallow compared to the other three and has only a small amount of deep water habitat. One notable difference among the reservoirs is that the lower two normally fluctuate by no more than 3 feet over a weekly period while the upper two reservoirs fluctuate by no more than about 5 feet. However, these fluctuation levels are not large relative to many other reservoirs in the Columbia River System (BPA et al., 1995). Furthermore, fluctuations are minimized (about 1 foot) near the Minimum Operating Pool (MOP) elevation during the spring and early-summer salmonid outmigration period.

Resident fish in the reservoirs occupy numerous habitats and often use separate habitats during different life history stages (Bennett et al., 1983; Bennett and Shrier, 1986; Hjort et al., 1981; Bennett et al., 1991). Each reservoir has three general zones

Table 4.5-4 Physical Characteristics of Lower Snake River Reservoirs

	Ice Harbor	Lower Monumental	Little Goose	Lower Granite
Distance of Dam from Snake R. Mouth (mi)	9.7	41.6	70.3	107.5
Normal Pool Elevation (ft)	440	540	638	738
Normal Pool Fluctuation (ft)	3.0	3.0	5.0	5.0
Reservoir Length (mi)	31.9	28.7	37.2	43.9
Surface Area (acres)	9,002	4,690	10,825	8,448
Maximum Depth at Normal Pool (ft)	110	130	135	138
Mean Depth at Normal Pool (ft)	48.6	57.2	56.4	54.4
Maximum Width (ft)	5,280	4,220	4,700	3,700
Mean Width (ft)	2,000	1,900	1,700	2,110
Major Tributaries	None	Palouse R., Tucannon R.	None	Clearwater R.
Reservoir Name	Lake Sacajawea	Lake Herbert G. West	Lake Bryan	N/A

Source: Bennett et al., 1983

characterized by different habitat characteristics (Zimmerman and Parker, 1995): the forebay zone, which is typically lake-like in nature; the tailrace zone, which tends to be shallower and have significant water velocities; and the mid-reservoir zone which is a transitional area between the tailrace and forebay zones. Lower Granite does not strictly have a tailrace zone because it is the most upstream of the four reservoirs. However, its upper reach does have many riverine characteristics comparable to the tailrace zone. Each zone can include several habitat types; however, most can be characterized as either backwater (including sloughs and embayments) or open-water habitats (Hjort et al., 1981; Bennett et al., 1983; La Bolle, 1984).

Backwaters and embayments generally provide low water velocity, slightly warmer water, finer substrate, and submersed and emergent vegetation. Bass, black crappie, white crappie, bluegill, pumpkinseed, yellow perch, and carp use backwater areas for spawning and rearing (Bennett et al., 1983; Bennett and Shrier, 1986; Hjort et al., 1981; Bennett et al., 1991; Zimmerman and Rasmussen, 1981). The centrarchids normally spawn in shallow water less than 6.5 feet deep (Bennett et al., 1983) while yellow perch generally utilize waters less than 10 feet deep (Stober et al., 1979). Spawning nests are found on a variety of substrate types ranging from silt and mud to rubble (Bennett et al., 1983). Yellow perch have shown a preference for spawning on submerged vegetation, providing it is silt-free (Nelson and Walburg, 1977; Muncy, 1962). The lack of suitable spawning vegetation has been hypothesized as a limiting factor in some Montana reservoirs, prompting the use of discarded Christmas trees to enhance production (EA Engineering, 1992). Spawning and incubation times vary between species; however, most of these backwater species spawn from May through mid-July (Technical Appendix B, Resident Fish).

The cyprinids, suckers, and possibly redside shiner spawn in open water. White sturgeon spawn over areas with rocky bottoms and high water velocity (Parsley et al., 1993). Prickly sculpin spawn in both open water and backwater, based upon the distribution of larvae (Hjort et al., 1981). The greatest abundance of larvae is

generally found in the backwaters and nearshore areas. Only yellow perch and prickly sculpin larvae are commonly found in open-water areas.

Most of the native species spawn in flowing waters in the tailwater of the next upstream dam, in tributary streams, or in free-flowing mainstem waters (Lower Granite only). Some species, however, may also spawn in the reservoirs. For instance, northern pikeminnow and kokanee may spawn either in flowing water or along gravel beaches in reservoirs (Wydoski and Whitney, 1979). However, no significant kokanee spawning beaches have been identified in any of the four lower Snake River reservoirs. Kokanee do not appear to be self-sustaining within any of the reservoirs, but are occasionally observed in Lower Granite as a result of entrainment through Dworshak Dam located on the North Fork Clearwater River.

Juvenile fish are found in abundance in backwater and open-water areas where flowing water is found. The two habitats are occupied by distinctly different fish species. Introduced species, which are primarily lake-dwelling fishes, are more common in the forebay zone and backwater areas while native riverine species are more common in the flowing water regions found in the tailrace zone (Hjort et al., 1981; Bennett et al., 1983; Bennett and Shrier, 1986; Mullan et al., 1986).

Adult distribution is generally similar to spawning and juvenile distribution, but can change depending upon feeding strategy. Adults may occur throughout the habitats and move seasonally or daily to different areas (Bennett et al., 1983; Bennett and Shrier, 1986; Hjort et al., 1981). Although adults will use various habitats, lake-dwelling species are generally more abundant in shallow, slower velocity backwater areas and native riverine species occur abundantly in areas with flowing water (Bennett et al., 1983).

To aid in the analysis of the alternatives, the fish species found in the lower Snake River have been placed into five habitat-use guilds (Table 4.5-3; Technical Appendix B, Resident Fish). The selection of guilds is based upon the expectation that particular habitat types would be present following implementation of one of the alternatives and the assumption that grouped species exploit stream resources in a similar manner (Leonard and Orth, 1988). The use of guilds explicitly generalizes habitat requirements by lumping common attributes and does not consider microhabitat differences known to exist among the species. The simple habitat guild system that was developed (Technical Appendix B, Resident Fish) is provided in Table 4.5-5.

Native fish inhabiting the lower Snake River reservoirs tend to be categorized in the riffle/rapids guild or head of pool/run guild. In contrast, the introduced species more commonly occur in the shallow mid/lower pool guild or slough/backwater guild. Smallmouth bass are the major exception to these general patterns. Smallmouth bass are considered habitat generalists and do not conveniently fit in just one or two of the described guilds. In general, the backwater areas have the greatest abundance of fish in all life stages. Deep habitats support fewer fish. The majority of the species found in deeper waters are suckers and minnows. White sturgeon are also found in deeper waters. Mid-depth habitats support a community higher in species diversity and abundance than deep habitat, but generally lower in abundance than shallow habitat (Bennett et al., 1991).

Table 4.5-5. Characteristics of Habitat Use Guilds for Resident Fish Currently Present in the Snake River System

Guild	Velocity	Substrate	Depth	Zone
Riffle/Rapids Guild	Higher (>2.0 feet/second) in areas of steep or moderate channel slope	Large (cobble/boulder) due to lack of deposition of finer materials	Varies, but generally use areas less than 10 feet deep	Tailrace zone
Head of Pool/Run Guild	Moderate and variable (0.5 to 2.0 feet/second); "head of pool" areas represent transitional habitats between swift areas of rapids and the deeper, slower main portions of the pools	Variable and dependent on velocities (higher velocities result in coarser substrate), but generally smaller particles (cobbles and gravel) than those in rapids, with only minimal deposition of fines and limited embeddedness	Use shallow areas less than 10 feet deep	Tailrace and mid-reservoir zones
Shallow Mid/ Lower Pool Guild	Less than 0.5 feet/second	Variable, but should range among the smaller-sized particles (gravel, sands, and some silt)	Use shallow areas less than 10 feet deep	Littoral areas within the mid and lower reservoir zones
Deep Mid/Lower Pool Guild	Less than 0.5 feet/second	Finer substrates (fine gravel, sand, and silt)	Prefer waters greater than 10 feet deep	Open water within the mid and lower reservoir zones
Slough/Backwater Guild	Little or no current	Variable, typically with a high fines component; this contributes to the development of macrophytes that add to habitat complexity	Sloughs and backwaters may be shallow or provide a full range of depths	Any of the three reservoir zones where sloughs or backwaters are present

Little Goose and Lower Monumental have a greater number of backwater areas than Lower Granite and Ice Harbor (Bennett et al., 1983). The confluence of two major tributaries (Palouse and Tucannon rivers) with the Snake River provide additional backwater habitat in Lower Monumental. Therefore, these reservoirs tend to support larger numbers of species that depend upon these shallow-water habitats during some part of their life histories. Channel catfish and carp are more abundant in Lower Monumental and Ice Harbor. Their abundance in these reservoirs is believed to be related to the availability of suitable habitat (waters with little current, often soft

substrates with emergent and submerged aquatic vegetation). Yellow perch are also more abundant in reservoirs with aquatic vegetation. Smallmouth bass, pumpkinseed, and white crappie are more abundant in upriver reservoirs (Bennett et al., 1983). The mouths of the Palouse and Tucannon rivers where they enter the Snake River provide access to flowing water for native species in Lower Monumental. The confluence of the Clearwater and Snake rivers provides important flowing water habitat in Lower Granite. The native species primarily spawn in the tributaries; however, headwaters of reservoirs serve a similar function. For example, in Lower Granite, northern pikeminnow migrate upstream to the lotic (flowing water) conditions in the Snake and Clearwater rivers. In other reservoirs without major tributaries (such as Little Goose), fish migrate to the tailwaters of the next dam upstream for spawning and possibly feeding benefits. Although no data were found to compare relative abundance of native species in the four reservoirs, the availability of flowing water habitat in Lower Granite and Lower Monumental would provide better habitat for native species than Little Goose and Ice Harbor.

Most of the dominant sport fishes in the lower Snake River reservoirs require high-quality, shallow-water (6.5 feet or less) habitats for spawning and rearing (Bennett et al., 1983; Bennett and Shrier, 1986). In addition to the requirement of shallow-water habitat, that habitat must also remain inundated throughout the incubation period to ensure good egg survival and the presence of submerged and emergent vegetation is beneficial. Fluctuations in water surface elevation can, therefore, have potentially large effects on spawning success, particularly in April through July when most shallow-water species spawn. However, Bennett et al. (1983) found that project operations during 1979 and 1980 appeared to have little effect on recruitment into the sport fishery. During this period, standard operating procedures maintained relatively small fluctuations, usually less than 5 feet for Lower Granite and Little Goose and less than 3 feet for Lower Monumental and Ice Harbor (Bennett et al., 1983; Corps, 1995a).

Water temperature is a factor that is critical for the success of most resident fish species inhabiting the reservoirs (Technical Appendix B, Resident Fish). Water temperature is a key stimulus for the onset of spawning for many of the species and controls the development of eggs into free-swimming fry. Water temperature can also influence the availability of prey items and the growth of juvenile fish. Temperature fluctuations are hypothesized to be the major factor influencing year-class strength (Technical Appendix B, Resident Fish). Many of the warm-water fish species have evolved to spawn during increasing water temperatures. Flow augmentation from upstream reservoirs designed to speed passage of migrating salmonids also reduces water temperatures. Reduced water temperatures can delay spawning times and shorten the growing season. Large water temperature fluctuations can be stressful to young-of-the-year fish, further stunting their growth. These effects can result in young-of-the-year fish that may be too small to survive over-wintering.

4.5.2.3 Aquatic Food Chain

Benthic Organisms

One part of the aquatic ecosystem, the benthic community (or benthos), consists of organisms that live on the bottom of lakes or rivers. Benthic plants such as algae and benthic animals such as insects, worms, snails, and crayfish are components of this community. Benthic organisms contribute significantly to the diets of many reservoir fish species (Bennett et al., 1983); they are essential elements in the food chain. In particular, crayfish were an important component to the diet of smallmouth bass, northern pikeminnow, and channel catfish in Little Goose and Lower Granite Reservoirs (Bennet et al., 1983). Benthic production is usually minimal in shallow-water areas if the water levels fluctuate and expose the organisms. As a result, benthic organisms will die along shorelines, for example, where water levels have substantial fluctuations (Mullan et al., 1986).

Frest and Johannes (1992) listed seven species of mollusks inhabiting the lower Snake River, of which six are native. The most abundant species they observed was the introduced Asian clam. In addition, they listed 34 native species that were known or likely to be present historically, suggesting that diversity has declined dramatically. Several mollusk populations that are part of the Columbia River Basin benthic community have been identified by the USFWS as species of concern. These are the California floater and the Columbia pebble-snail.

Phytoplankton and Zooplankton

Two other very important parts of the food chain include phytoplankton and zooplankton. The phytoplankton, or drifting plants, are microscopic algae that nourish themselves from the energy of the sun (Barnes, 1980). They are at the base of the food chain. Phytoplankton can be seen in surface waters when large colonies bloom and form a green film. They provide a food source for bacteria, water molds, and zooplankton. Zooplankton are tiny, floating transparent animals (Barnes, 1980). Both phytoplankton and zooplankton are a food source for larger aquatic organisms, such as snails and small fish. In addition, fish species such as white crappie, black crappie, and redside shiner feed directly on zooplankton which compose an important component to their diet (Bennett et al., 1983).

The use of backwater areas by numerous species may be at least partially related to the availability of prey. High concentrations of zooplankton in the backwater areas attract smaller prey species that feed upon these organisms. In turn, high concentrations of prey fish attract larger predator fish species. Therefore, higher concentrations of zooplankton in backwater areas may affect the habitat selection of several species.

Factors thought to influence zooplankton abundance in Lake Roosevelt on the upper mainstem Columbia River include photoperiod, water temperature, and water retention time (Peone et al., 1990) and a similar relationship is likely true for the lower Snake River reservoirs. Higher primary production leads to increased secondary (e.g., zooplankton) and higher trophic level production. Water retention time was considered to be the most critical of the three factors in Lake Roosevelt

because it is directly influenced by dam operations within the system (Peone et al., 1990). The lower Snake River dams have relatively low storage volumes (i.e., they are run-of-river) and water retention times are driven by the operation of storage dams elsewhere in the system. During spring floods, water velocities are generally high and waters are vertically mixed. Long water retention times reduce the amount of plankton flushed from the reservoir. Backwaters and embayments have slower water velocities and somewhat warmer water, allowing the development of higher density plankton populations compared to mid-reservoir and tailwater areas. Longer water retention times during late spring and summer also encourage the development of vertically stratified waters which help to keep phytoplankton within the photic zone or upper depths within which adequate sunlight is available for photosynthesis (Barnes, 1980). Releases of cool water during low flow years to augment juvenile salmon passage can also reduce the production of plankton.

Aquatic and Terrestrial Plants

Aquatic plants include phytoplankton (described above), algae, and macrophytes. Each of these plant types are important components to the primary production within the reservoirs. Filamentous green algae can be found attached to rocks, woody debris, and other structures. Filamentous green algae was described as part of the diet for several of the fish species in the Little Goose reservoir, but was not prominent in any diet (Bennett et al., 1983). Filamentous algae historically present in the natural river bed have been partially replaced by diatoms, a type of phytoplankton with unicellular or colonial forms. Although diatoms have become very abundant in the reservoirs, their size or structure has prevented their use as a major food source by macroinvertebrates.

Macrophytes are large vascular aquatic plants that grow in shallow water along the shorelines of lakes or in the slow-moving reaches of rivers. Macrophytes can be entirely submerged or emergent. Emergent macrophytes are an important element in the food chain because they provide homes for insects, which in turn can be food for fish, and they function as a direct food source for many aquatic organisms. Macrophytes also supply surfaces for fish eggs to incubate as well as protection for fish species during various life stages. These plants are especially important for young fish that hide among plant stems and leaves to escape predators. Additionally, macrophytes help stabilize shorelines by reducing erosion and recycling nutrients, an important function in nutrient-poor areas.

In many reservoir systems, fish abundance in shallow waters has been shown to correlate with the presence of macrophytes. However, the results of studies conducted at Little Goose (Lake Bryan) by Bennett et al. (1983) did not indicate a positive correlation between fish abundance and macrophytes except for yellow perch and carp. There is very little aquatic macrophyte production in Lower Granite Lake.

Terrestrial plants growing adjacent to the reservoirs can contribute woody debris, leaf litter, and other organic debris that can be utilized as cover, substrate, and nutrients by invertebrate and vertebrate aquatic fauna if it falls into water. However, terrestrial plants generally do not contribute directly to fish diets. A notable exception is the presence of wheat in the diets of channel catfish, northern pikeminnow, and redside shiner (Bennett et al., 1983). At some locations, wheat ranked as high as second or

third in importance for catfish and northern pikeminnow in Lake Bryan. Apparently, this food item results from losses occurring during transport by barge through the reservoirs.

Fish Predation

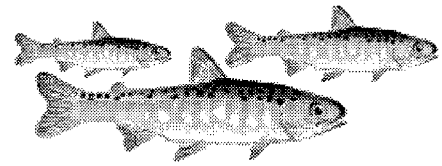
Fish predation occurs by species that occupy the highest trophic level of the aquatic food web. The most important piscivorous fish species include smallmouth bass, northern pikeminnow, channel catfish, crappies, and yellow perch. Individuals of these species can forage on a variety of smaller species. Of particular importance, the larger individuals may seasonally forage on juvenile salmonids residing in, or migrating through, the reservoirs. However, other than fall Chinook, fish predation appears to be relatively low in yearling Chinook and Steelhead. The most significant predator on juvenile salmonids are smallmouth bass because of their abundance (Technical Appendix B, Resident Fish). Salmonids were reported as an important component to the diet of channel catfish (Bennett et al., 1983; Bennett et al., 1988), but little is known about catfish abundance and the total amount of salmonid predation they may incur. Predation by northern pikeminnow has been reduced substantially in the lower Columbia and Snake rivers in recent years as the result of high harvest levels supported by the Sport Reward Program and scientific sampling funded by BPA (Friesen and Ward, 1999). However, overall predation of salmon in Lower Granite pool and tailrace by northern pikeminnow is very low (Naughton, 1998).

Sport Fishery for Resident Fish

A sport fishery has developed within the four lower Snake River reservoirs. In a recent 1997 survey, most anglers (73 percent) pursued adult steelhead (University of Idaho et al., 1997). For those anglers pursuing resident fish, targeted species included channel catfish (26 percent), smallmouth bass (18 percent), and rainbow trout (14 percent). Surveys conducted in 1979 and 1980 on Lake Bryan indicated that crappies and white sturgeon are also species targeted by fishermen (Bennett et al., 1983). Although yellow perch were rarely sought by fishermen during 1979 and 1980, they were an important component to the catch, particularly by shore-based fishermen.

4.5.2.4 Resident Fish Species Listed Under ESA

Bull trout, a species listed as threatened under the ESA, have occasionally been recorded at lower Snake River dam passage facilities (Kleist, 1993; Hurson, 1999). Bull trout are also currently found in Dworshak Reservoir (Maiolie et al., 1988), the Tucannon River, Grande Ronde River, and Asotin Creek (WDFW and Western Washington Treaty Indian Tribes, 1998). Consequently, bull trout probably used the lower Snake River during a portion of the year prior to dam construction, but the extent of this historical utilization would be speculative. Bull trout usually require very cold waters (less than 59°F); (Rieman and McEntyre, 1993) throughout the year. A few individuals of the species for each year since the mid-1990s have been documented passing through the ladder at Little Goose dam (Corps et al., 1999; Corps data available on request; USFWS, 1998a).



4.6 Terrestrial Resources

4.6.1 Vegetation

This section describes vegetation resources within the lower Snake River study area. Many factors, including water level, sediment composition, and river flow affect the abundance, distribution, and species composition of wetland, riparian, and associated upland vegetation zones (Gosselink and Mitsch, 1993; Brinson et al., 1981). Because the proposed alternatives may affect hydrology, this section describes the existing vegetation and habitats that may be potentially altered by structural and/or operational changes to the Lower Snake River Project.

The study area is located within the Columbia Basin physiographic province and includes two major vegetation zones—steppe and shrub-steppe (Franklin and Dyrness, 1973). Steppe communities are dominated by bunchgrasses, such as Idaho fescue, bluebunch wheatgrass, and Sandberg's bluegrass, while shrub-steppe communities are co-dominanted by sagebrushes, such as big sagebrush. Prior to construction of dams and impoundments, rich alluvial soils associated with the Snake

River floodplain allowed the development of quality riparian vegetation along the river. Over 50 vegetated islands were present in the study area, with sand and gravel bars common (Technical Appendix M, Fish and Wildlife Coordination Act Report).

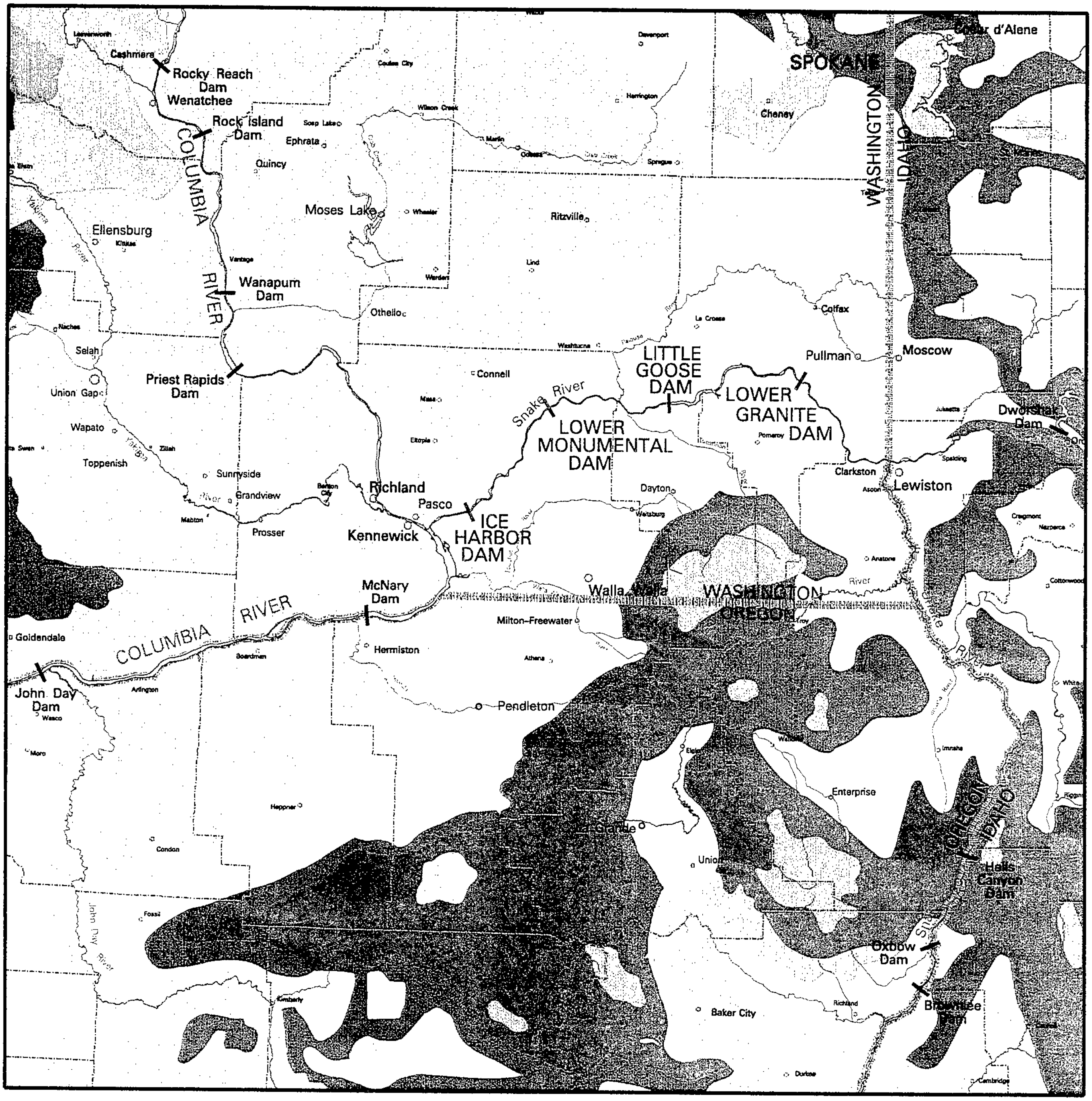
Many wetlands have been modified, degraded, or destroyed over the last 100 years by land use practices and manipulation of hydrology. Human activities such as railroad construction, road construction, livestock grazing, and agricultural have adversely impacted vegetation in the study area. Regional vegetation is shown on Figure 4.6-1

The construction of dams and impoundments reduced the native upland and riparian habitats within the study area. Emergent wetland types increased significantly after construction of dams and impoundments due to sedimentation and flooding of backwater areas (by approximately 350 acres—see Table 4.6-1). Approximately 13,772 acres were inundated by impoundment in the reservoirs (Table 4.6-1). Currently, the study area contains approximately 18,150 acres of upland habitat, 1,800 acres of riparian habitat, and 963 acres of wetland habitat (including ponds).

Table 4.6-1. Acreages of Habitat Types within the Boundaries of the Lower Snake River Project Based on Cover Type

	Area (Acres)	
Habitat Type	**Pre-project (1958)**	**Post-impoundment (1995)**
Upland		
Cropland and Pasture	4,643.3	307.1
Grassland	13,258.7	9,406.4
Forbland and Planted Grassland	1,915.7	650.5
Shrub-steppe	7,674.3	5,331.7
Exposed Rock and Rock Talus	3,096.4	2,453.5
Total Upland Habitat	*30,588.4*	*18,149.2*
Riparian		
Mesic Shrub	837.3	752.1
Palustrine Forest	710.8	459.1
Palustrine Scrub-shrub	1,736.6	592.3
Total Riparian Habitat	*3,284.7*	*1,803.5*
Wetland		
Palustrine Emergent	9.9	353.2
Palustrine Open Water (ponds)	293.7	609.4
Total Wetland Habitat	*303.6*	*962.6*
Reservoir/River	*19,464*	*33,236*
Total Project Lands	***53,640.7***	***54,151.3***

Source: USFWS (1991) and cover typing completed by USFWS and Corps in 1995



Source: "Potential Natural Vegetation of the Conterminous U.S." by A.W. Kuchler, 1964

NEEDLELEAF FOREST
- Western Ponderosa
- Douglas Fir
- Cedar – Hemlock – Pine
- Grand Fir – Douglas Fir
- Western Spruce – Fir

GRASSLANDS
- Fescue – Wheatgrass
- Wheatgrass – Bluegrass
- Alpine Meadow and Barren

SHRUB & GRASSLAND COMBINATION
- Sagebrush – Steppe

KM 300 100 0 MILES 7.5 15 30

125,000 ACRES

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

1 : 1,900,800

DRAFT

Lower Snake River
Juvenile Salmon Migration Feasibility Study

Figure 4.6–1. REGIONAL VEGETATION

GIS Analysts & Graphic Assembly: Applied Technology Team (CENWW-PM-PD-E)
g:\regional\reg\plates\lsr\jsmeis\lsrg\lsrgveg.dgn:GISFILE PLOTTED: 07 DEC 1999

1999

4.6.1.1 Riparian Communities

The riparian zone lies adjacent to streams and rivers and is influenced by the stream and its associated groundwater (Malanson, 1993). This includes areas with woody vegetation, which are too dry to be classified as wetlands, sand and gravel bars, wet meadows, flood-scoured areas, and other stream-related habitats and vegetation. Riparian areas serve as important wildlife habitat and are integral to the function of river aquatic ecosystems, wind shelters for residences, and locations for recreational activities.

The extent and type of riparian vegetation occurring in the study area depend on water availability. Water availability (e.g., precipitation) increases with elevation from downstream to upstream ranging from approximately 9 to 15 inches. Greater precipitation in the upstream area facilitates a richer band of riparian vegetation in the side draws and shallow pockets across the canyon slopes in the upper half of the study area. Also, north-facing slopes retain more moisture than other slopes and often have more diverse vegetation and more extensive woody vegetation.

Before any impoundments were constructed on the lower Snake River, there were approximately 3,285 acres of riparian vegetation (Table 4.6-1, Figure 4.6-2). This habitat was composed of riparian forest, palustrine scrub-shrub, and mesic shrubland. Typical riparian forest included black cottonwood, white alder, black locust, and netleaf hackberry. Mesic shrubland occurred in side draws and areas with at least seasonal springs and seeps. Species typical of these areas included netleaf hackberry, douglas hawthorn, chokecherry, and willows. Additionally, riparian areas included forbland composed of species such as teasel, curly dock, and water hemlock. Much of this vegetation was found in discontinuous bands along the main river at the bottom of the canyon or in the side canyons associated with seeps and springs.

Currently, approximately 1,804 acres of similar habitat types occur in varying proportions (Table 4.6-1, Figure 4.6-3). Species composition has also changed somewhat reflecting intrusion of invasive species such as Canada thistle, false indigo, black locust, and Russian olive. Both Russian olive and black locust were used as part of the original mitigation plantings. The invasion is primarily from these plantings.

Several factors have contributed to the lack of development of extensive riparian areas along the lower Snake River. The steep shorelines along the project reservoirs and areas of the shoreline covered in riprap are primarily responsible for limiting development of riparian communities. Furthermore, extensive grazing (Lewke and Buss, 1977), the expansion of railroads, and the gradual inundation of the river bottom by dams have also limited riparian vegetation to narrow vegetation corridors and backwater areas. These particular changes have reduced the extent of many of the woody plant communities such as cottonwood, willow, and white alder that once characterized the riparian zone. In addition to riparian vegetation that remained above the newly established water line, riparian vegetation has been artificially recreated through the use of irrigation on 11 Habitat Management Units (HMUs) scattered throughout the reach. (see Section 2.1.1.8, Lower Snake River Fish and Wildlife Compensation Plan and Section 4.6.2, Wildlife).

Figure 4.6-2. Pre-project (1958) Acreage of Vegetation Types in the Study Area

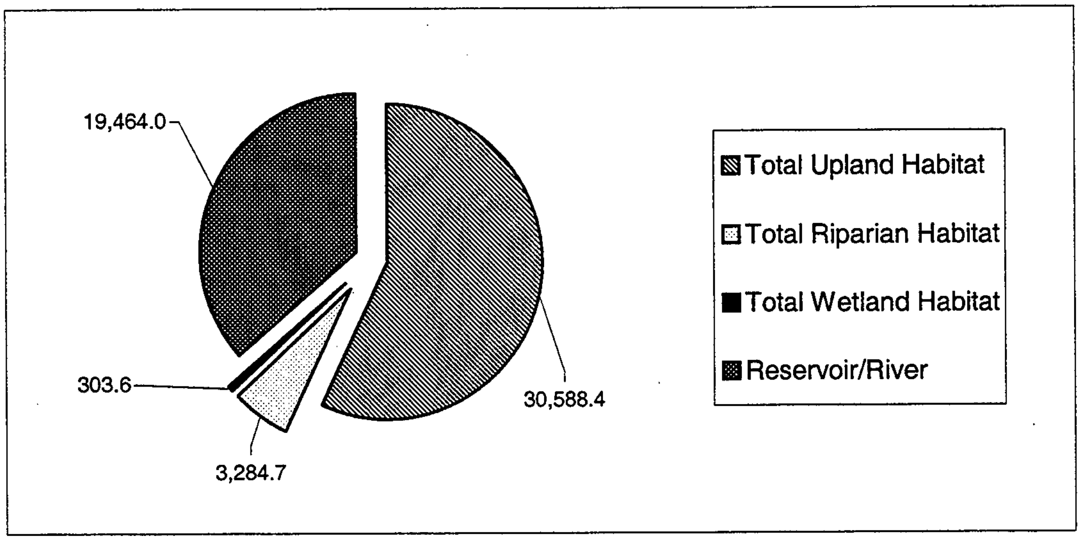
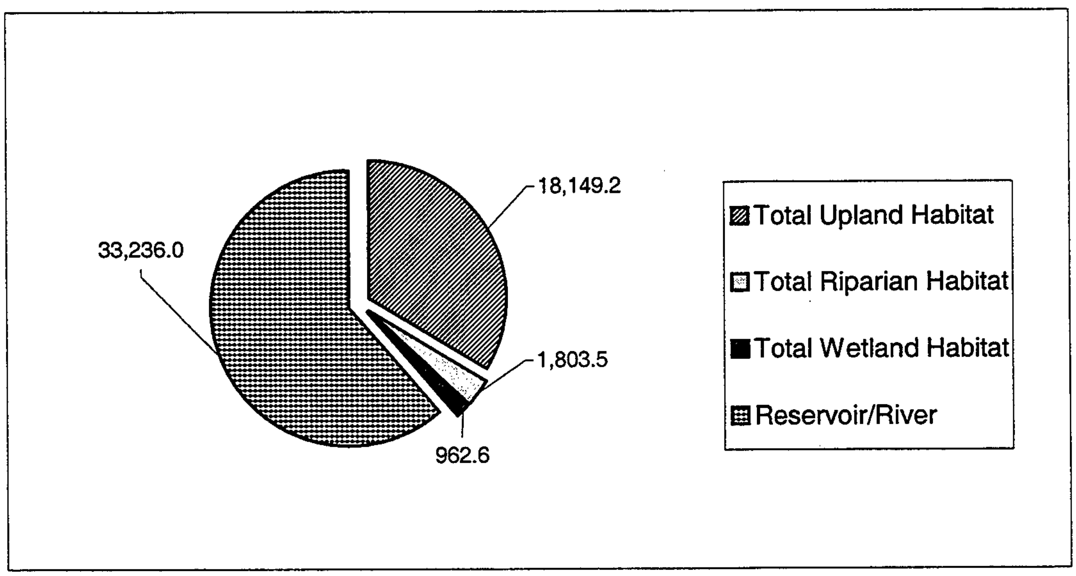


Figure 4.6-3. Current (1995) Acreage of Vegetation Types within the Study Area



4.6.1.2 Emergent Wetland Community

In contrast to riparian habitats, which usually have water saturated soils during flood events, wetlands generally occur where groundwater saturates the surface layer of soil during a portion of the growing season, often in the absence of surface water. This water remains at or near the surface of the substrate for periods of sufficient duration and frequency to induce the development of characteristic vegetative, physical, and chemical conditions (16 USC Sec.440b Title 16, ch. 64).

Wetlands along the river and inside stream deltas serve a variety of physical and biological functions including: wildlife habitat (waterfowl, big game, furbearers, etc.), fish breeding and foraging habitat, nutrient/sediment trapping, flood control, and recreation.

The amount and occurrence of emergent wetland vegetation has increased since the four dams were constructed, from about 10 acres in 1958 to 353 acres currently (Table 4.6-1, Figure 4.6-3). Additionally, numerous small pockets of wetland vegetation less than one-half acre in size (not mapped due to small size) exist in small impoundments behind roads and railroads and small embayments. Vegetation is dominated by cattail and softstem bulrush with some rushes and sedges. The increase in emergent wetland communities is likely due to several factors: 1) abundant slack water which causes sediments carried into reservoirs to accumulate and create good conditions for wetland vegetation development, especially at the mouths of tributaries; 2) several embayments and backwaters which also allow wetland development; 3) drawdowns which allowed wetland vegetation to establish; and 4) runoff and seeps from nearby irrigated HMUs.

4.6.1.3 Upland Community

The upland vegetation in the study area is typical of steppe communities in the Columbia Basin Province, which are dominated by rabbitbrush, cheatgrass, and remnant bunchgrasses and forbs. Prior to reservoir construction, much of the upland habitat had been degraded by overgrazing with livestock. Also, some vegetation had been removed to facilitate farming and orchards. Pockets of native grassland vegetation (bluebunch wheatgrass-Sandberg's bluegrass community) remained on very steep slopes and other areas inaccessible to grazing; otherwise, much of the native vegetation had been replaced with cheatgrass. Approximately 12,439 acres of upland vegetation were inundated by the four reservoirs (Table 4.6-1).

Currently, 18,149 acres of upland habitat exist within the study area (Table 4.6-1). Grassland represents the largest habitat type present within the study area and includes approximately 9,406 acres. Topographic relief increases from the lower to upper end of the reach reflecting increasing proportions of rock cliff and talus slopes. Fencing of project lands has eliminated cattle grazing on some plant communities (mostly grassland), encouraging re-establishment of some of the native plants. Shrub-steppe habitat present in the study area includes approximately 5,332 acres. Characteristic vegetation of this habitat includes big sagebrush, gray rabbit brush, and cheatgrass.

Currently, about 307 acres of agricultural land (i.e., cropland and pasture) are present in the study area. Included in this habitat type are lands being managed specifically for wildlife that include a mixture of alfalfa, grass pastures, and food plots. The food

plots are primarily small patches of crops which are rotated between corn, sunflower, and grain sorghum. Wheat and millet are also used sometimes in the food plots.

4.6.2 Wildlife

The study area for wildlife resources encompasses the four reservoirs along the lower Snake River as well as the wetland, riparian, and upland habitats within the canyon of the river (see Section 4.6.1, Vegetation, and Figures 4.6-4a through d). The study area contains some of the most important wildlife habitat remaining in Eastern Washington because most of the upland areas outside the canyon are intensively cultivated for crops such as wheat, barley, and lentils. Asherin and Claar (1976) identified 87 species of mammals and 257 species of birds that occur in the vicinity of the lower Snake River. Although the canyon has been intensively grazed in the past, particularly between the 1880s and late 1930s (Asherin and Claar, 1976), upland vegetation in the canyon is still important for the maintenance of healthy populations of wildlife, particularly upland game bird species such as pheasant, chukar, and quail.

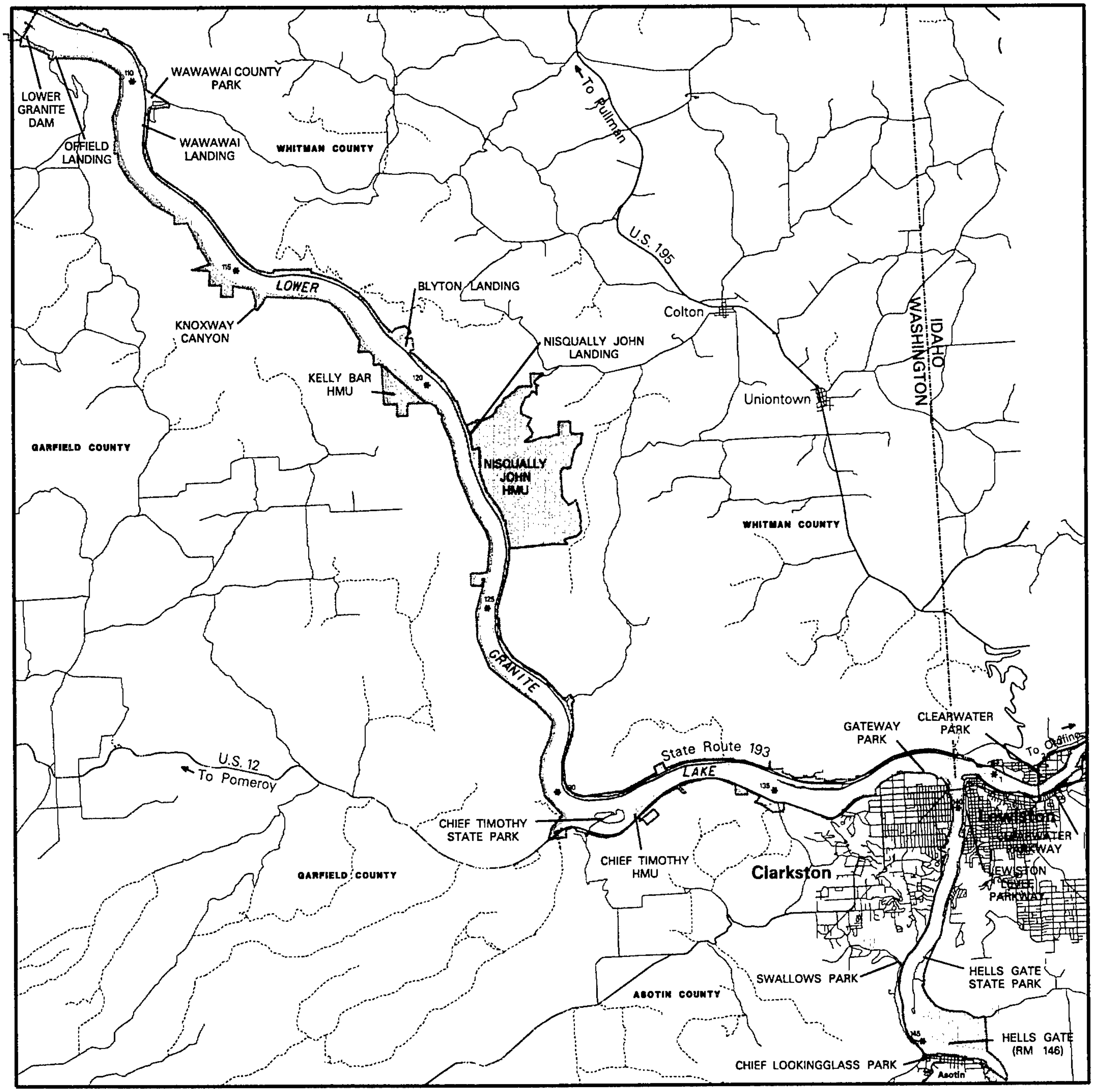
Inundation of the lower Snake River following dam construction between 1962 and 1975 eliminated approximately 45 percent of the woody riparian habitat present along the pre-impoundment river (Asherin and Claar, 1976; Technical Appendix L, Lower Snake River Mitigation and History and Status). The remaining riparian habitat is now highly discontinuous and dominated by exotic species such as Russian olive (see Section 4.6-1, Vegetation).

Some riparian habitats have been restored through the establishment of HMUs along the river (Figures 4.6-4a through d; Table 4.6-2). Thus, wildlife generally associated with riparian habitats tends to be concentrated in these HMUs and in the natural vegetation along the major tributaries, such as the Tucannon and Palouse rivers.

Current wildlife resources are described below according to the following major groups of terrestrial species that exist in the study area: game birds, waterfowl, shorebirds, colonial-nesting birds, raptors, other non-game birds, big game animals, small mammals, furbearers, amphibians and reptiles, and listed threatened or endangered species. These groups were chosen to facilitate the results of this analysis with the results of the existing Habitat Evaluation Procedures (HEP) that have been undertaken for the Lower Snake River Fish and Wildlife Compensation Plan. These groups are not intended to be exclusive. They are simply intended to provide basic species groupings for the purposes of discussion.

4.6.2.1 Current Terrestrial Mitigation and Habitat Evaluation Procedures

The Lower Snake River Fish and Wildlife Compensation Plan (Comp Plan) was developed to compensate or mitigate for fish and wildlife losses from constructing the four lower Snake River reservoirs (see Section 2.1.1.8, Lower Snake River Fish and Wildlife Compensation Plan). Other terrestrial mitigation in Idaho was covered in a separate agreement (see Technical Appendix L, Lower Snake River Mitigation History and Status). Initially, mitigation goals were defined by animal numbers and hunter-use days. However, concerns arose over use of this method for determining compensation (USFWS, 1991). Subsequently, it was determined that a habitat-based



USACE LAND CLASSIFICATIONS

Recreation

Wildlife

Other

BOUNDARY

Project

TRANSPORTATION

US & State Highways

Secondary Roads

Other Roads

Railroads

KILOMETERS 3 2 1 0 MILES 1 2 3

1,500 ACRES 750 375

GEOGRAPHIC INFORMATION SYSTEMS Corps of Engineers Walla Walla District

1 : 190,080

DRAFT

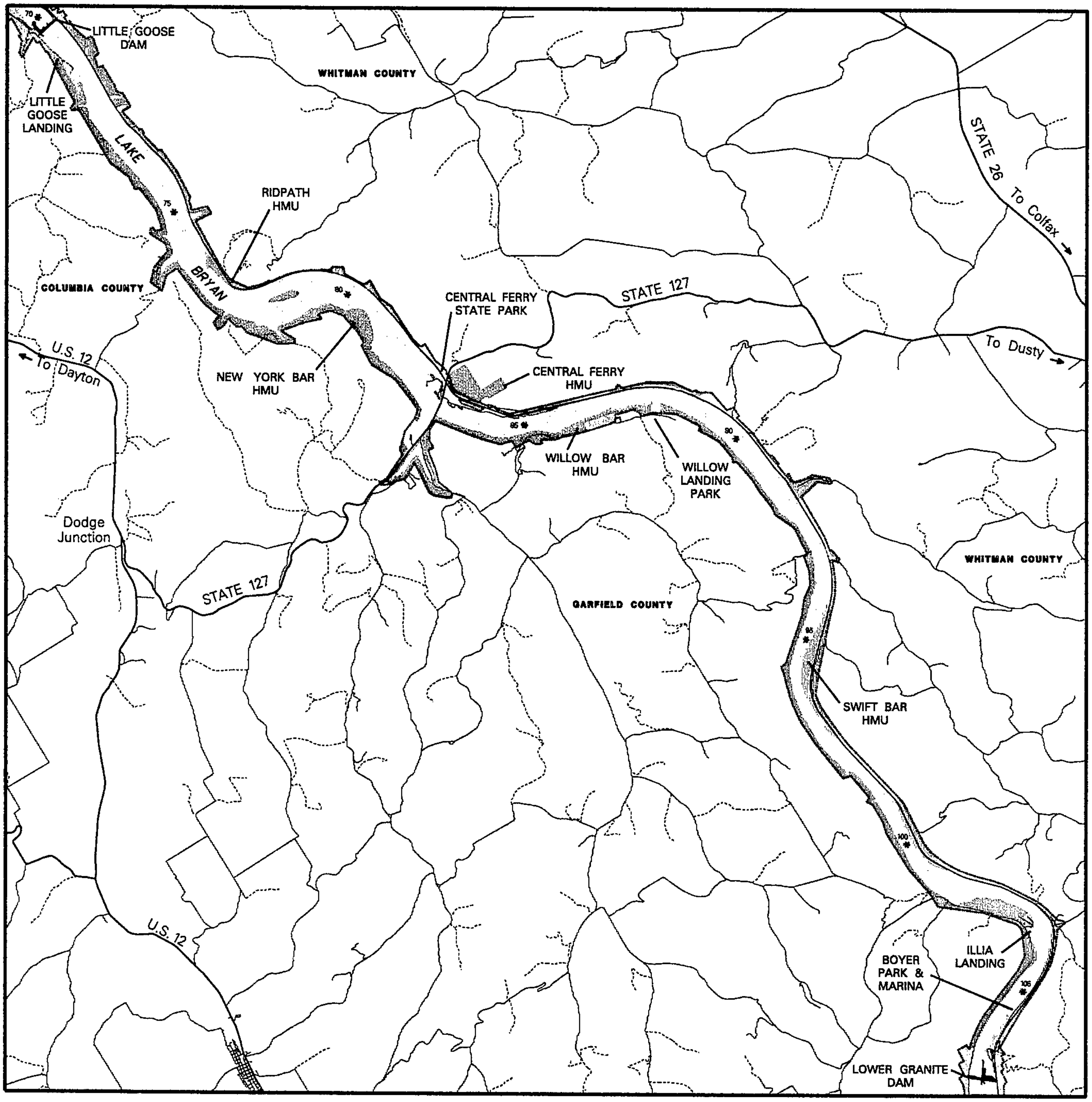
Lower Snake River

Juvenile Salmon Migration Feasibility Study

Figure 4.6–4a.
LOWER GRANITE LAKE LAND CLASSIFICATION

1999

GIS Analysts & Graphic Assembly: Applied Technology Team (CENWW-PM-PD-E)
g:\lgranite\lla\plates\jsmeis\eisllalc.dgn:GISFILE PLOTTED: 07 DEC 1999



USACE LAND CLASSIFICATIONS

Recreation

Wildlife

Other

BOUNDARY

Project

TRANSPORTATION

US & State Highways

Secondary Roads

Other Roads

Railroads

KILOMETERS 3 2 1 0

MILES 1 2 3

1,500 ACRES

750

375

1 : 190,080

GEOGRAPHIC INFORMATION SYSTEMS

Corps of Engineers

Walla Walla District

DRAFT

Lower Snake River

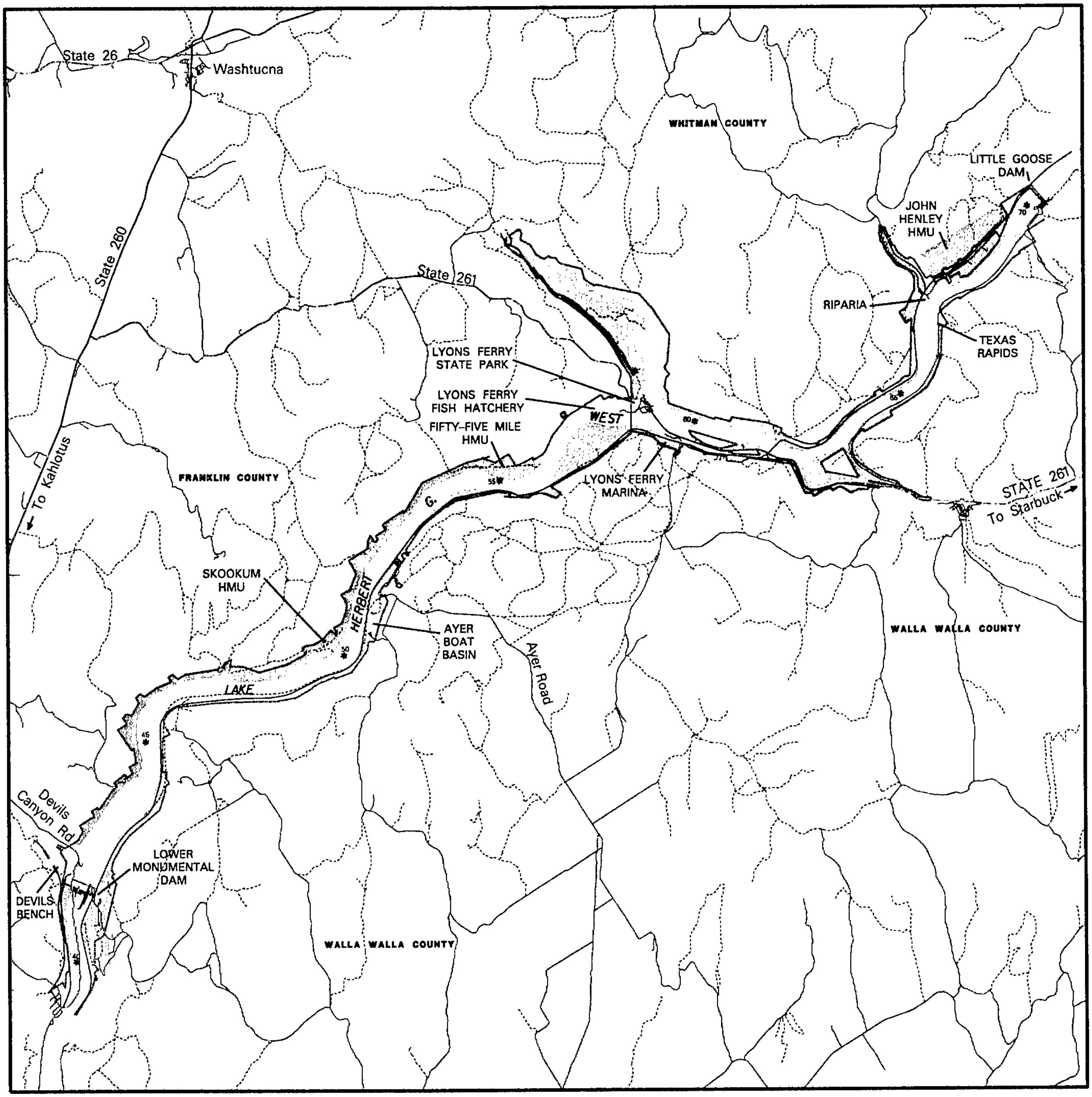
Juvenile Salmon Migration Feasibility Study

Figure 4.6–4b.

LAKE BRYAN LAND CLASSIFICATION

1999

GIS Analysts & Graphic Assembly: Applied Technology Team (CENWW-PM-PD-E)
g:\goose\lga\plates\jsmeis\eislgalc.dgn:GISFILE PLOTTED: 07 DEC 1999



USACE LAND CLASSIFICATIONS

Recreation

Wildlife

Other

BOUNDARY

Project

TRANSPORTATION

State Highways

Secondary Roads

Other Roads

Railroads

KILOMETERS 3 2 1 0 MILES 1 2 3

1,500 ACRES

375 750

1 : 190,080

GEOGRAPHIC INFORMATION SYSTEMS Corps of Engineers Walla Walla District

DRAFT

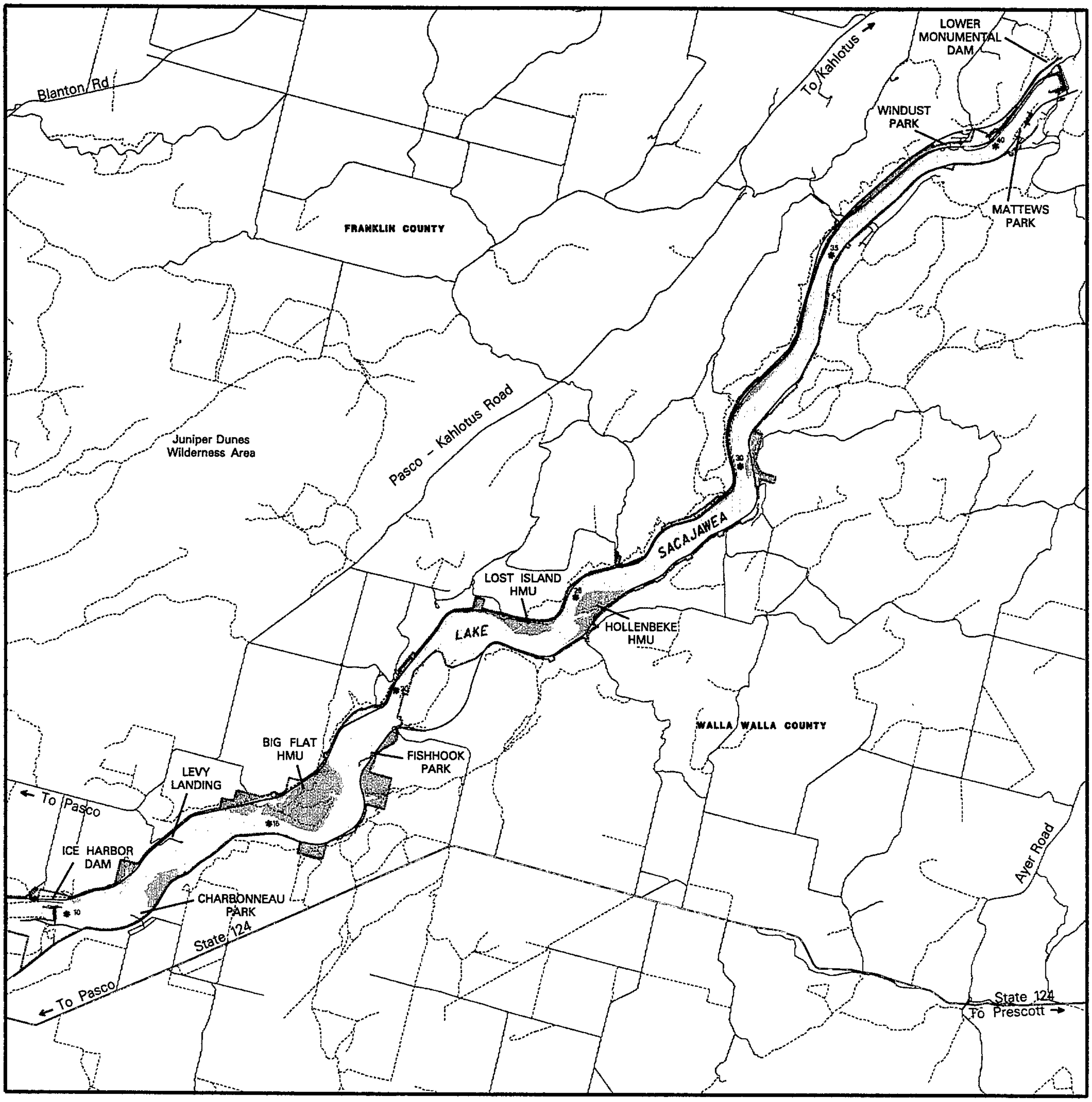
Lower Snake River

Juvenile Salmon Migration Feasibility Study

Figure 4.6–4c. LAKE WEST LAND CLASSIFICATION

1999

GIS Analysts & Graphic Assembly: Applied Technology Team (CENWW-PM-PD-E)
g:\lmonumental\lma\plates\jsmels\eislmalc.dgn:GISFILE PLOTTED: 07 DEC 1999



USACE LAND CLASSIFICATIONS

- Recreation
- Wildlife
- Other

BOUNDARY

- Project

TRANSPORTATION

- US & State Highways
- Secondary Roads
- Other Roads
- Railroads

KILOMETERS 3 2 1 0 MILES 1 2 3

1,500 ACRES 750 375

1 : 190,080

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

DRAFT

Lower Snake River
Juvenile Salmon Migration Feasibility Study

Figure 4.6–4d. LAKE SACAJAWEA LAND CLASSIFICATION

GIS Analysts & Graphic Assembly: Applied Technology Team (CENWW-PM-PD-E)
g:\iceharbor\hid\plates\jsmeis\eishldlc.dgn:GISFILE PLOTTED: 07 DEC 1999

1999

Table 4.6-2. Habitat Management Units and Areas by Reservoir

Reservoir	Habitat Management Unit	Acres	Reservoir River Mile
Ice Harbor	Headquarters	1	9.7
	Charbonneau	100	11
	Lake Charlene	57	12
	Levey	30	13
	Big Flat	895	14.7-18
	Quarter Circle	89	16
	Fishhook	217	18
	Nineteen Mile	25	19
	Lost Island	162	22-25
	Hollebeke	247	24-26
	Snake River Junction	26	26
	Walker	89	30
	Couch Landing	93	29-34
	Matthews Island	1	40
	Subtotal	**2,032**	
Lower Monumental	Megallon	132	45
	No Name	500	45
	Skookum	764	47-53
	Ayer	185	52-55
	55 Mile	295	55-56
	Joso	568	56.5-58
	Lyons Ferry	42	58
	Joso East	58	58.8-60
	Tucannon	240	62-63
	Texas Rapids	54	66-67.2
	Riparia	413	67-67.5
	Alkali Flat Creek	211	67.3
	John Henley	919	67.5-69
	Subtotal	**4,381**	

Table 4.6-2. Habitat Management Units and Areas by Reservoir Page 2 of 2

Reservoir	Habitat Management Unit	Acres	Reservoir River Mile
Little Goose	Little Goose Landing	320	70.5-72
	Browns Gulch	90	75.2
	Hangar-Dry Gulch	145	75.3-76
	Ridpath	64	75.9-77.4
	Phalen-New York Gulch	184	77.3-78.3
	New York Island	47	78.1-78.8
	New York Bar	210	78.3-81.7
	Central Ferry	296	83.4-84.5
	Deadman/Meadow Creek	219	83
	Purrington	72	85-86.5
	Willow Bar	191	86-88.5
	Penawawa	74	91.5-91.8
	Rice Bar	143	91.8-94
	Swift Island	0.25	94.4-94.5
	Swift Bar	364	94-97.5
	Beckwith Bar	111	97.7-99.4
	Shultz Bar	138	99.5-101
	Illia	351	101.5-103
	Subtotal	**3,019.25**	
Lower Granite	Transmission Line	79	108.5-110
	Knoxway Canyon	41	116
	Kelly Bar	585	119.5-121.2
	Centennial Island	2.5	119.8
	Nisqually John Canyon	3,077	120.9-125
	No Name	30	123-124.2
	Moses	44	129-130
	Alpowa Creek	81	130.5
	Chief Timothy Island	0.2	131.3
	Chief Timothy	66	131.3-133.2
	Silcott	160	131.3-133.2
	Wilma Water Tank	22	134-135
	Confluence Island	6.5	138.2-138.3
	Asotin Slough	79	146.5-147
	Hells Gate	650	143.8-146.8
	Clearwater River Goose Pasture Lower	47	5.5-6.5
	Clearwater River Goose Pasture Upper	32	7.3-8.2
	Subtotal	**5,002.2**	

Source: Technical Appendix L, Lower Snake River Mitigation History and Status, Annex 2: Tabulation of Facilities of Lower Snake River Comp Plan Lands

method should be used to establish compensation goals and measure compensation progress. This was formalized in a Letter of Agreement (LOA) signed by the Corps, USFWS, and Washington Department of Wildlife (now the WDFW) in 1989. These agencies agreed to use a modified HEP method.

HEP is a species-based habitat analysis procedure, that normally involves representatives from several agencies or other groups. The USFWS, Corps, and WDFW were all actively involved in this procedure. HEP assesses the value of a given habitat for certain selected species over the life of the project. The species evaluated are selected either to represent entire groups of species (for example, river otter was chosen to represent furbearers), because of some special value they have in the area (for example, popular game birds), or to evaluate a certain habitat type. The evaluation species that were chosen included 12 birds and mammals, including: downy woodpecker, yellow warbler, marsh wren, song sparrow, western meadowlark, California quail, ring-necked pheasant, chukar, mallard, Canada goose, mule deer, and river otter. Technical Appendix L, Lower Snake River Mitigation History and Status identifies the species group or habitat type represented by each of these species and provides more detail on the HEP methodology.

Terrestrial wildlife habitat mitigation is divided into several programs. These include Lower Snake River Project land (which involves lands immediately adjacent to the reservoirs) development program; the purchase of additional lands and easements; and the game farm program. The Lower Snake River Project lands have been developed using a combination of dryland and irrigation techniques. The Corps has purchased additional lands and easements in southeast Washington, and has begun developments on them. These developments include food plots, pastures, grass meadows, and shrub and tree plantings to improve habitat for both game and non-game wildlife species. The game farm alternative is a program where the WDFW sets up lease agreements with landowners in southeast Washington to improve ring-necked pheasant habitat on their lands (see Technical Appendix L, Lower Snake River Mitigation History and Status for more detail).

4.6.2.2 Game Birds

The major game bird species occurring in the study area include ring-necked pheasant, California quail, chukar, and mourning dove, of which only the mourning dove is native (Asherin and Claar, 1976; Rocklage and Ratti, 1998). These game birds are relatively common throughout the study area, extending from the riverside to the upland areas. Chukars use a wide variety of habitats in the study area. Oelklaus (1976) found that chukars use Douglas hackberry, smooth sumac, and poison ivy stands along the Snake River extensively. Shrub and talus areas are important for nesting (USFWS, 1995). Cheatgrass and agricultural grains are important for foraging (Galbreath and Moreland, 1953; Christensen, 1970). Access to water is probably the most limiting factor for chukar distribution in the study area (Galbreath and Moreland, 1953).

Ring-necked pheasants depend on permanent shrub and tall herbaceous cover that is maintained on irrigated lands in the study area. They are often found in the irrigated HMUs foraging on food plots.

The California quail has experienced more habitat loss than the other species as a result of inundation by the Lower Snake River Project. This species has an estimated loss of 18,861 habitat units (HUs) that remain uncompensated since dam construction and mitigation development. This outstanding mitigation need exceeds the amounts for any other single wildlife species or group in the study area. In comparison, the pheasant and chukar have approximately 2,118 and 877 HUs still uncompensated, respectively. The pheasants and quail tend to be found most often in the irrigated HMUs, such as Swift Bar HMU, where their populations are supported by food plots of various crops like sunflower, grain, and corn as well as permanent water sources called "guzzlers." Of a total of 62 HMUs scattered along the Snake River from Ice Harbor Dam to the upper extent of the Lower Granite pool, 10 are subject to intensive management. Within these 10 intensively managed HMUs, approximately 960 acres of food plots, meadows, and woody vegetation plots are under irrigation.

4.6.2.3 Waterfowl

Over 30 species of waterfowl have been documented to occur in the study area (Lewke and Buss, 1977; Asherin and Claar, 1976; Rocklage and Ratti, 1998). Although impoundment of the river has not significantly changed the species composition of waterfowl along the river (the most abundant species are still Canada goose, mallard, common goldeneye, and American wigeon), it has affected the abundance and occurrence of these species both negatively and positively. In general, the increase in consistent slack water has provided more loafing and resting sites, but has eliminated feeding and nesting sites by removing riparian vegetation. However, the increase in abundance of cereal grain fields both in HMUs along the river and in the adjacent uplands has provided a consistent source of food, particularly for mallards and Canada geese. Of the four reservoirs, Ice Harbor usually has the most waterfowl (see Technical Appendix M, Fish and Wildlife Coordination Act) probably due to its protection as a waterfowl preserve. HEP analysis has demonstrated that approximately 2,060 HU of uncompensated losses for Canada geese exist along the river, compared to 52 HU of compensation exceeding losses for mallards (see Technical Appendix L, Lower Snake River Mitigation History and Status).

Much of the management focus on waterfowl along the lower Snake River has been for Canada geese. Therefore, much more is known about the population status of this species than any other single species. Canada goose nesting has been documented on cliffs, on islands and on artificial nesting structures along the river. Surveys conducted between 1974 and 1987 on the lower Snake and Columbia rivers have found that over 80 percent of Canada goose production was supported on Badger, Foundation, and New York islands on the Columbia River (Boe, 1988). New York Island alone has averaged 70 to 80 nests over the years, but numbers have declined in recent years. Foundation and Badger islands averaged 80 to 100 nests each year. Island nesting on the lower Snake River produced about 125 nests in 1996. The surveys also found an average of 88 nests per year in all four reservoirs, compared to a pre-impoundment average of 220 (Yocum, 1961). This reduction in nest production can be attributed to the inundation of over 50 islands larger than 5 acres by the reservoirs. Cliff nesting appears to be an increasing trend since impoundment (see Technical Appendix M, Fish and Wildlife Coordination Act Report), probably in response to loss of predator-free island nesting sites. Artificial nest structures along most of the HMUs have regular annual use. In 1996, goose tubs (large nest boxes

elevated above river level on poles) produced 45 nests on the lower Snake River. Total lower Snake River nesting currently is about 200 nests per year.

4.6.2.4 Shorebirds

Shorebirds are relatively uncommon breeders along the lower Snake River (Smith et al., 1997); their use of the reservoirs is limited by the small amount of sandbars and mudflats available (USFWS 1991; Asherin and Claar, 1976). At least one study has shown that use of shorelines by shorebirds on reservoirs and natural lakes in the intermountain west is closely associated with the availability of exposed mudflats (Taylor and Trost, 1992). Potential suitable habitat for shorebird breeding in the vicinity of the study area includes Lake Kahlotus, and the McNary Wildlife Refuge, as well as Foundation, Badger, and Crescent Islands on the Columbia River (Smith et al., 1997). Pre-impoundment, only killdeer and spotted sandpiper were seen along the sand and gravel bars of the river with any regularity (see Technical Appendix M, Fish and Wildlife Coordination Act Report). Asherin and Claar (1976) only noted four species in Lower Granite Reservoir prior to inundation. Recent surveys (Rocklage and Ratti, 1998) found killdeer, spotted sandpiper, and common snipe in the area during the breeding season, lesser and greater yellowlegs in the fall, and killdeer and long-billed curlew in the spring. The most abundant species observed by Asherin and Claar (1976) in the study area was the American avocet. Asherin and Claar (1976) observed 28 American avocets during the spring of 1974. The most abundant shorebird species observed by Rocklage and Ratti (1998) was the killdeer. Fifty-eight individuals of this species were observed in the spring season. The HEP analyses did not address shorebirds.

4.6.2.5 Colonial-nesting Birds

Colonial-nesting birds include marine species such as gulls, caspian tern, and double-crested cormorant, but also inland species such as great blue heron and cliff and bank swallows. No known rookeries for any of these species occur on the lower Snake River, with the exception of several sites listed as "possible" breeding sites in the *Breeding Bird Atlas of Washington State* (Smith et al., 1997). Apparently, the double-crested cormorant bred along the river pre-impoundment, but has not been recorded since inundation (Weber and Larrison, 1977). Several of these species breed on the large islands at the mouth of the Snake River (in the vicinity of McNary Wildlife Refuge), but the lack of islands and mature riparian forest as well as fluctuating water levels has probably kept these species from breeding along the reservoirs of the lower Snake River. Both black-crowned night herons and great blue herons have been observed foraging in shallow water areas and in agricultural areas in the study area. Two other species that do occur in the vicinity of the study area are white pelican and double-crested cormorant. White pelicans have had a small nesting colony (20 to 40 nests) on Crescent Island since at least 1994 (Ackerman, 1994). This is the only known nesting population of white pelicans in Washington state and they are a state-listed endangered species. These birds are occasionally seen in the shallow water areas in the study area, most often near Ice Harbor Dam on the western edge of the study area. Double-crested cormorants have nested on Foundation Island in the McNary Pool since at least 1988 with a colony size of between 5 and 125 nests (USFWS, 1997). This species is also occasionally observed foraging in the study area, often in Dalton Lake at Big Flat HMU.

Significant colonies of cliff and bank swallows occur at a number of locations along the river. Bank swallows are usually present wherever there are exposed cutbanks suitable for nesting that are consistently above water level. Cliff swallows nest both on steep rock faces and in the dam structures themselves. The HEP analyses did not address colonial-nesting birds.

4.6.2.6 Raptors

The study area supports a diverse raptor population. Some of the species that have been documented include northern harrier, Swainson's hawk, red-tailed hawk, American kestrel, ferruginous hawk, prairie falcon, and golden eagle. Several of these species, including prairie falcon, golden eagle, kestrel, and Swainson's hawk, nest on cliffs and rocky crevices in the study area (Smith et al., 1997; Asherin and Claar, 1976; WDFW, 1999a). Others, including the ferruginous hawk, nest and forage in the open grasslands and shrubby draws (WDFW, 1999a). Rocklage and Ratti (1998) documented 17 species of raptors in the study area, including 209 individuals of 12 species during the breeding season. Of these 209 individuals, over 80 percent were one of three species: red-tailed hawk (45 percent), American kestrel (21 percent) and northern harrier (14 percent).

Asherin and Claar (1976) found 14 raptor species along the lower Snake River, with one species, burrowing owl, not reported by Rocklage and Ratti (1998). Asherin and Claar (1976) found 225 individuals, with American kestrel (43 percent) and red-tailed hawk (44 percent) the most common species in the study area.

Lewke and Buss (1977) documented species including Cooper's hawk, northern harrier, red-tailed hawk, rough-legged hawk, kestrel, and great horned owl in the vicinity of Lower Granite Reservoir. Asherin and Claar (1976) did not observe three of these species (rough-legged hawk, Cooper's hawk, and great horned owl) in the vicinity of Lower Granite Reservoir. The HEP analyses did not address raptors.

4.6.2.7 Other Non-Game Birds

There is some evidence that bird species richness along the lower Snake River has declined from pre-impoundment conditions. Of 61 total bird species found by Dumas (1950), 12 were not reported by a recent study (Rocklage and Ratti, 1998). These species include the black-chinned hummingbird, veery, red-eyed vireo, solitary vireo, American redstart, Brewer's blackbird, and fox sparrow. Most of these species are associated with riparian forest habitat (Smith et al., 1997). It is possible that some of these species are not currently found along the river because of the lack of mature riparian forest and the predominance of exotic species such as Russian olive (USFWS, 1997).

Several studies (USFWS, 1997; Brown, 1990) have shown that native willow habitat provides both better foraging and nesting habitat for most bird species. This may be partially explained by the more diverse shrub and tree composition of native riparian areas compared to the low diversity Russian olive habitat (USFWS, 1997; Geupel et al., 1993).

Asherin and Claar (1976) found riparian habitats to have the highest bird species richness and the most individuals during winter along the lower Snake River. Riparian habitats in Washington have been identified as priority areas for monitoring,

research, and management of neotropical migratory birds (NTMB) (Andelman and Stock, 1994). Eighty-nine species of NTMB have been recorded along the lower Snake River (see Technical Appendix M, Fish and Wildlife Coordination Act Report), including most of the species identified as experiencing long-term declines in Washington, such as the ferruginous hawk, golden eagle, killdeer, eastern kingbird, barn swallow, golden-crowned kinglet, gray catbird, solitary vireo, orange-crowned warbler, yellow warbler, Wilson's warbler, and chipping sparrow (Andelman and Stock, 1994).

Rocklage and Ratti (1998) observed a total of 92 bird species during the breeding season within the study area. Within the various habitats along the river, the HMUs (consisting primarily of riparian shrub habitat) had higher bird species richness during both the breeding season and the fall than the woody drainages leading into the reservoirs. The suitability of the woody drainages for foraging and nesting may be limited by their narrow width and their degradation by intensive cattle grazing. Therefore, despite the lack of mature riparian habitat on the HMUs, they still provide important habitat for riparian bird species. In particular, the irrigated HMUs provide important habitat. For example, Rocklage and Ratti (1998) found 10 species of birds in the irrigated HMUs that were absent from the non-irrigated HMUs. The availability of food plots on the HMUs also probably offsets some of the negative habitat value of the non-native habitat. The improvement in habitat quality in the HMUs, and along the lower Snake River in general, is further evidenced by comparing the results of this study with those of Asherin and Claar (1976). Rocklage and Ratti (1998) detected 24 more bird species along the Snake River from Lower Monumental Dam to Clarkston, Washington during summer, 40 more in fall, and 14 more in spring.

The HEP analyses addressed six non-game bird species, which represented six different cover types (see Table 4.6-3). The HEP analyses reveal that the value of the habitat provided on compensation lands for 3 of the 6 species, including the marsh wren, song sparrow, and western meadowlark (as measured in habitat units), exceeds the losses incurred by the inundation habitat by the reservoirs (see Table 4, Technical Appendix L, Lower Snake River Mitigation History and Status). These species represent emergent wetland, mesic shrubland, and shrub-steppe grassland cover types, respectively.

Very little emergent wetland habitat existed pre-impoundment (see Table 4, Technical Appendix L, Lower Snake River Mitigation History and Status), and impoundment actually created more of this habitat type than existed before impoundment. Shrub-steppe grassland and mesic shrubland cover types have both benefited from development of purchased compensation lands.

The following species and their habitats have uncompensated losses: downy woodpecker (riparian forest), song sparrow (riparian forest understory), and yellow warbler (scrub-shrub wetland). Of these three species, the yellow warbler has the largest deficit (710 HUs) and the song sparrow has the least uncompensated losses (15 HUs). The biggest deficit, therefore, is with cavity-nesting species and species that rely on native riparian shrub and tree communities. In order to thrive in this region, the yellow warbler needs native willow/cottonwood and the downy woodpecker needs native riparian forest (with some decadence).

Table 4.6-3. Threatened and Endangered Plant and Animal Species Potentially Occurring within the Study Area

Common Name	Scientific Name	Status[1/]	Primary Habitat Association	Occurrence
Plants				
Water howellia	*Howellia aquatilis*	Threatened	Small isolated ponds and river oxbows	Possible
McFarlane's four-o'clock	*Mirabilis macfarlanei*	Threatened	Grassland dominated by bluebunch wheatgrass	Possible
Ute ladies' tresses	*Spiranthes diluvialis*	Threatened	Wetland and riparian areas	Possible
Howell's spectacular thelypodium	*Thelypodium howellii var. spectabilis*	Proposed		
Basalt daisy	*Erigeron basalticus*	Candidate		
Animals				
Bald eagle	*Haliaeetus leucocephalus*	Threatened	Nests mainly in tall, dead-topped conifers or snags near large bodies of water; in winter, forages along major river systems in Washington and Oregon	Documented in winter; no known breeding occurrences
Oregon spotted frog	*Rana pretiosa*	Candidate		
Gray wolf	*Canis lupus*	Endangered	Restricted to remote wilderness areas free of human disturbance with abundant prey	Possible
Grizzly bear	*Ursus horribilis*	Threatened	Remote, mountainous areas with low-level human disturbance	Possible
Canada lynx	*Lynx canadensis*	Proposed		

1/ Status from USFWS species list (1998e)

Source: Foster Wheeler Environmental Corporation (1999)

4.6.2.8 Big Game Mammals

Mule and whitetail deer are the two most common big game species found along the lower Snake River. Other species that have been observed along the river but that are considered uncommon to rare include elk, bighorn sheep, black bear, moose, and mountain lion. An estimated 1,800 mule and white-tailed deer inhabited the study area prior to inundation (WDG, 1984). The WDFW estimated that inundation reduced the carrying capacity of the study area by 1,200 deer (Corps, 1975). Aerial winter deer counts conducted by the Corps and WDFW between 1978 and 1988 along the four reservoirs found an average of 3,547 deer per year or an average of 9.2 deer per square mile (Corps, 1990). Mule deer made up approximately 80 percent of this population, with whitetail deer making up the remaining 20 percent. During this time, deer densities gradually increased, with a net increase of over 3,000 deer by 1988. The Corps (1990) suggests that this means that the study area recovered to its pre-project carrying capacity. This increase is at least partly due to the development of habitat in the HMUs and the exclusion of livestock from much of the study area.

Suitable habitat for deer in the study area mainly serves as wintering range, with the deer making seasonal and daily migrations out of the canyons to forage in the surrounding cultivated land. While in the study area, deer use a wide variety of habitats, including shrub and brush for cover and fawning and grassland for foraging. There is some evidence that greater precipitation and higher habitat diversity along the upper two reservoirs provide more stability for deer populations than habitats downstream (Corps, 1990).

Habitat development in irrigated HMUs (e.g., Skookum, 55-Mile) has provided some higher quality habitat in Ice Harbor and Lower Monumental reservoirs. Furthermore, HMUs could be considered excellent habitat for fawning as they provide dense shrub habitat for cover, food plots for foraging, and close proximity to water (Thomas, 1979). It is unknown if mule or white-tailed deer use existing islands as fawning habitat in the study area. Only New York Island may provide suitable cover for fawning although there has been no evidence of deer use in the last 15 years. Currently, the winter deer range provided by the HMUs is considered to be low to moderate quality, based on HEP analysis (USFWS, 1991). Nonetheless, the most recent HEP analysis available (see Technical Appendix L, Lower Snake River Mitigation History and Status) demonstrates that current compensation habitat in the study area for the big game species group (which is based on the mule deer model) outweighs pre-dam habitat losses by approximately 534 HUs. Notably, epizootic hemorhagic disease has recently caused severe mortality in the white-tailed deer population, although estimates of deer numbers lost are not currently available and losses are expected to be short term in nature.

4.6.2.9 Small Mammals

Eleven small mammal species have been observed in the study area, with two additional species likely present. These species include the deer mouse, western harvest mouse, Great Basin pocket mouse, house mouse, long-tailed vole, montane vole, northern pocket gopher, vagrant shrew, Merriam's shrew, bushy-tailed woodrat, and Ord's kangaroo rat (Rocklage and Ratti, 1998; Johnson and Cassidy, 1997; Asherin and Claar, 1976; Fleming, 1981). Pre-impoundment data from a study done on the Lower Granite Reservoir (Lewke and Buss, 1977) found seven species, of

which the deer mouse made up the majority of captures (93 percent). Asherin and Claar (1976) found only deer mice at the Lower Granite Reservoir site prior to impoundment. Overall, deer mice made up 70 percent of the total numbers of small mammals trapped in their 1974 study. Post-impoundment studies have found similar results. Rocklage and Ratti (1998) found six species, with deer mouse composing 74 percent of total captures. Notably, some evidence suggests that small mammals prefer native riparian habitat to other habitat. Asherin and Claar (1976) found the highest species diversity in their study in the native cattail and shrub willow habitat types. One species, vagrant shrew, is known to be dependent on riparian areas (Johnson and Cassidy, 1997; Technical Appendix M, Fish and Wildlife Coordination Act Report).

Six species of bats have been documented in the study area and five more are suspected to occur there based on habitat suitability, their range, and their occurrence in the vicinity (Johnson and Cassidy, 1997; Mack et al., 1994, Asherin and Claar, 1976). Documented species include the Yuma myotis, western pipistrelle, pallid bat, small-footed myotis, California myotis, and Townsend's big-eared bat (Asherin and Claar, 1976; Johnson and Cassidy, 1997).

Other species of bats that may also be present include the long-legged myotis, long-eared myotis, fringed myotis, hoary bat, and big brown bat (Johnson and Cassidy, 1997; Asherin and Claar, 1976). The Yuma myotis, long-legged myotis, long-eared myotis, small-footed myotis, fringed myotis, and Townsend's big-eared bat are all listed as species of concern by the USFWS (USFWS, 1998a). The Townsend's big-eared bat is also a candidate for state listing (WDFW, 1999b).

Although the known or suspected species of bats in the study area use a wide variety of habitats, there are some trends. Townsend's big-eared bat is thought to be dependent on caves or mines for both winter and summer roosting (Perkins and Levesque, 1987; Philpott, 1997). It preys primarily on moths and seems to require still lakes, ponds, or pools to obtain water, as it flies low and laps water with its tongue (Perkins and Schommer, undated). Most of the other species use a wider range of locations, including caves, mines, trees, buildings, bridges, dams, and rock crevices as roost sites (Philpott, 1997; Christy and West, 1993). Bats have been known to roost in the dams in the study area. At least one species, the western pipistrelle, is closely associated with the steep canyon walls and rock crevices in the study area and utilizes these habitats for roosting (Johnson and Cassidy, 1997). This observation is consistent with behavior of western pipistrelles in southern Arizona and southwestern New Mexico (Hayward and Cross, 1979). Most of these species will forage in a wide variety of habitats, including arid grassland, shrubs, trees, and over rocky areas (Johnson and Cassidy, 1997).

At least one species, Yuma myotis, is closely associated (more so than any other species) with water, and tends to forage close to the surface of the water (Johnson and Cassidy, 1997; Maser, 1998).

4.6.2.10 Furbearers

Furbearing mammals that have been documented in the study area include bobcat, coyote, raccoon, red fox, striped skunk, beaver, river otter, mink, and muskrat (Asherin and Claar, 1976; Johnson and Cassidy, 1997; Mack et al., 1994). Coyote

and raccoons are the most common terrestrial species, and beaver is the most common aquatic furbearer.

Asherin and Claar (1976) observed four species of terrestrial furbearers (bobcat, coyote, raccoon, and striped skunk) and three species of aquatic furbearers (beaver, river otter, and muskrat). They concluded that aquatic furbearer abundance was low along the lower Snake River. Asherin and Claar (1976) also conducted scent station surveys along the lower Snake River in 1974, but unfortunately they were not conducted in the Lower Granite Reservoir site so no comparison to natural river conditions can be made. These surveys produced similar results to the direct observations, with raccoon and coyote the most common species observed. Asherin and Claar (1976) also noted that the aquatic furbearers were more abundant in those study segments with more extensive riparian habitat such as McNary Wildlife Refuge and Brownlee Reservoir.

Although it is likely that some of these species were never abundant (Asherin and Claar, 1976), inundation by the reservoirs probably eliminated much of the riparian habitat that was important for foraging and denning in many of the furbearers. In particular, muskrat and mink seem to have declined (WDG, 1984).

HEP analysis demonstrates that current compensation habitat in the study area for furbearers exceeds losses by approximately 866 HU (see Technical Appendix L, Lower Snake River Migration History and Status). The HEP analysis for furbearers was based on the model for the river otter. One of the reasons why compensation has exceeded losses is that riprap placed along the river for bank stabilization is considered to provide suitable denning habitat for otters (USFWS, 1995).

4.6.2.11 Amphibians and Reptiles

Sixteen species of amphibians and reptiles have been documented in the study area (Asherin and Claar, 1976; Loper and Lohmann, 1998; McKern, 1976). Asherin and Claar (1976) found 11 species of herptiles along the lower Snake River during surveys in 1974. These included 5 amphibian and 6 reptile species. The most commonly occurring species were the Pacific tree frog, bullfrog, western yellow-bellied racer, and Great Basin gopher snake. Furthermore, of the vegetation types sampled, the ones most closely associated with water had the greatest relative abundance of amphibians. In particular, native willow and emergent wetland habitats had the greatest species diversity (Asherin and Claar, 1976).

A recent 2-year study by Loper and Lohman (1998) found 5 amphibian and 8 reptile species in the study area. Species found in this study but not in Asherin and Claar's (1976) study were long-toed salamander, western toad, night snake, and painted turtles. Asherin and Claar (1976) found the Columbia spotted frog and Great Basin spadefoot toad, which were not found by Loper and Lohman (1998). Although Asherin and Claar (1976) did not find those four species in the study area, they did find them in other study segments. Thus, it might be expected that they could have dispersed into the study area, or, since Asherin and Claar (1976) only employed visual surveys, they were simply not detected.

Although the Columbia spotted frog is common in much of the Palouse region, it is generally absent from the lower Snake River area (Loper and Lohman, 1998; Johnson and Cassidy, 1997). Similarly, the Great Basin spadefoot toad is considered a

common resident of the Columbia River Basin, even though it was not discovered during the Loper and Lohman (1998) study (Johnson and Cassidy, 1997). Loper and Lohman (1998) observed the western painted turtle at only one site—the pond on the Chief Timothy HMU. Asherin and Claar (1976) only found this species at Hat Rock State Park on the Columbia River. Other species that may occur within the study area, but were not seen in either study, include: tiger salamander, northern leopard frog, short-horned lizard, sagebrush lizard, rubber boa, and the ringneck snake (Loper and Lohman, 1998; Johnson and Cassidy, 1997; Asherin and Claar, 1976).

Unlike Asherin and Claar (1976), Loper and Lohman (1998) found no increased abundance of amphibians or reptiles with riparian areas. They found that, in general, species richness and abundance were low at both riparian and upland sites. Some of the reasons behind this pattern may include the relative young age of the recovering riparian fringe beside the existing reservoirs; the isolation of suitable riparian habitat into discrete patches along the river (i.e., HMUs); and fluctuating water levels in the reservoirs that prevent the consistent occurrence of litter, debris, pools, and vegetation that these species could use for breeding, resting, and forage (Loper and Lohman, 1998). These conclusions are supported by studies on amphibians in other dammed river systems (Lind et al., 1996; Jones, 1988).

4.6.3 Species with Federal Status

The Endangered Species Act (ESA) (16 USC 1536), amended in 1988, establishes a national program for the conservation of threatened and endangered species of fish, wildlife, and plants and the preservation of the ecosystems upon which they depend. Section 7(a) of the ESA requires Federal agencies to consult with the USFWS and the NMFS, as appropriate, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their critical habitat.

Section 7(c) of the ESA and the Federal regulations on endangered species coordination (50 CFR § 402.12) also require that Federal agencies prepare biological assessments of the potential effects of major construction actions on listed or proposed endangered species and critical habitat.

There are 10 potentially affected species that have Federal status under the ESA as threatened or endangered (Table 4.6-3). These species are described below in Section 4.6.3.1, Threatened and Endangered Plant Species, and Section 4.6.3.2, Threatened and Endangered Wildlife Species.

4.6.3.1 Threatened and Endangered Plant Species

Five plant species with Federal status—water howellia, McFarlane's four-o'clock, Ute ladies' tresses, Howell's spectacular thelypodium, and basalt daisy—may potentially occur in the study area. Water howellia, McFarlane's four-o'clock, and Ute ladies' tresses are Federally listed as threatened, Howell's spectacular thelypodium is proposed to be listed, and the basalt daisy is a candidate for Federal listing.

Water Howellia

Water howellia, a Federally threatened species, is a small annual aquatic plant which is usually found in wetlands associated with glacier pothole ponds and former river oxbows (USFWS, 1994a). Generally this species is found in isolated seasonal ponds or river oxbows that may be abandoned or hydrologically linked to adjacent river systems. These seasonal wetland habitats usually exhibit some drying during the growing season, although some of the ponds may retain water throughout the year (USFWS, 1994a). This seasonal drying is critical to the phenology of this species, which reproduces solely from seeds that require air to germinate (USFWS, 1994a). Historically, howellia occupied a large area of the Pacific Northwest, extending from northern California to Washington and Montana. Currently, there are only 107 known populations. Most of these populations are concentrated in two regions—Spokane County, Washington and the Swan River drainage in northwestern Montana, where 46 and 59 individual populations are located, respectively (USFWS, 1994a). The closest population to the study area is approximately 60 miles north in Spokane County, Washington (USFWS, 1994a). The USFWS has not completed a recovery plan for this species at this time. These individual populations are considered to be vulnerable to disturbance and possible extirpation due to a variety of threats, including drainage of wetlands due to farming, damage from intense grazing, timber harvesting, residential development, and competition from exotic species (particularly reed canary grass) (USFWS, 1994a).

McFarlane's Four-o'clock

McFarlane's four-o'clock, a Federally threatened species, is known to occur only at sites on the lower Snake, Salmon, and Imnaha rivers, all upstream of the lower Snake River in Hells Canyon, which is about 30 miles from the study area (USFWS, 1996). It is apparently restricted to talus slopes in canyonland corridors where the climate is regionally warm and dry with precipitation occurring mostly in winter and spring (USFWS, 1996). Exotic plant species, particularly cheatgrass and yellow star-thistle, as well as intense livestock grazing pose serious threats to this species (USFWS, 1996). The USFWS has completed a recovery plan for this species.

Ute Ladies' Tresses

This perennial orchid is listed as Federally threatened. It has been documented in southeastern Idaho along the upper Snake River and in northern Washington. It is found in wetland and riparian areas, including spring habitats, mesic to wet meadows, river meanders, and floodplains, which are typically inundated early in the growing season but dry out later in the year (USFWS, 1992). This species may be adversely affected by modification of its habitat associated with livestock grazing, vegetation removal, excavation, construction activities, stream channelization, and other actions that alter hydrology or vegetation. The USFWS has not approved a recovery plan for this species.

Howell's Spectacular Thelypodium

This herbaceous biennial occurs in wet alkaline meadows in valley bottoms, usually near the boundary between upland and the wet meadow in association with woody shrubs. The species is currently known to exist in five populations in Baker and

Union County, Oregon, all of which are within 13 miles of the town of Haines, Oregon (USFWS, 1999). The closest population is approximately 100 miles from the study area. Major threats to this species include competition from exotic species such as teasel and thistle, conversion of suitable habitat to agriculture, and the use of herbicides and pesticides (USFWS, 1999). The USFWS does not have an approved recovery plan for this species.

Basalt Daisy

This herbaceous perennial is a candidate for Federal listing. It is a local endemic found only in cliff crevices in basaltic canyons at low elevations in Yakima County, Washington. The nearest known population is approximately 90 miles from the study area. Suitable habitat for this species is restricted to vertical basalt exposures. There are some potentially suitable vertical basalt cliffs for this species in the study area. Basalt cliffs make up a major portion of the approximately 2,400 acres of exposed rock and talus that currently exists in the project area (Table 4.6-1).

4.6.3.2 Threatened and Endangered Wildlife Species

Only one Federally listed wildlife species is known to occur in the study area—the bald eagle. Four additional Federally listed species, the gray wolf, grizzly bear, and Oregon spotted frog, and Canada lynx are not known to occur, but could potentially occur in low numbers. All five species are described below.

Bald Eagle

Suitable habitat for the bald eagle includes areas with large trees for roosting or nesting that are close to large bodies of open, ice-free water with a good prey base of fish and waterfowl (USFWS, 1986). Bald eagle nesting territories are usually associated with marine or freshwater shorelines where there are stable populations of fish and/or waterfowl for prey (USFWS, 1986). Nests are usually located in uneven-aged, multi-storied stands with old growth components (Anthony et al., 1982). Nest trees usually provide an unobstructed view of, and are usually within 1 mile of, a nearby water body (Anthony et al., 1982). Live mature trees with deformed tops and snags are often selected. Similarly, large trees or snags with strong branches and open structure in the vicinity of foraging areas are often selected for perch trees (Garrett et al., 1993; Anthony et al., 1982). No bald eagle nests are documented along the reservoirs. The nearest known nest and winter concentration sites are on the Columbia River bordering the Hanford Reservation.

Wintering birds are regularly seen in the study area, although sightings are not abundant. They are present in the study area between November and March. Wintering bald eagles are primarily associated with open water near concentrated food sources. Communal winter roost sites consist of concentrations of eagles within 1 mile of large bodies of water or along large rivers (Anthony et al., 1982). These sites are usually large pockets of old growth along a feeder stream to the large lake or Class I river. Large cottonwoods and conifers are the preferred tree species for use during winter (USFWS, 1997; USFWS, 1986; Stalmaster, 1976).

Midwinter bald eagle surveys by the Corps in 1990 reported 10 eagles on the lower Snake River. These birds are probably dependent on waterfowl and fish, as are eagles

at the Hanford Reach of the Columbia River (Fitzner and Hanson, 1979). Wintering bald eagles are more common in the middle and upper Snake River. The lack of mature cottonwood and black locust trees along the margins of the reservoirs probably limits the ability of bald eagles to successfully perch and forage along the lower Snake River.

Oregon Spotted Frog

The Oregon spotted frog is a candidate for Federal listing. It is native to the Pacific Northwest (Leonard et al., 1993). It was recently differentiated from a close relative, the Columbia spotted frog.

The Oregon spotted frog is closely associated with shallow, emergent wetlands associated with lakes, ponds, and slow-moving streams. Historically, this species was common in the lowlands of Puget Sound and the Willamette Valley, but its range has been reduced by almost 90 percent due to loss of wetlands from agriculture and development (McAllister and Leonard, 1997; Hayes, 1997). Of 11 known historic localities in Washington, the Oregon spotted frog has only been found at one, in Thurston County. Two new populations have been found in Klickitat County. No populations are known to occur near the study area. The major threats to this species include predation by exotic species, mainly bullfrog, continued destruction of potentially suitable wetland habitat, overgrazing, and residential development (McAllister and Leonard, 1997).

Gray Wolf

Gray wolves have two main life requisite requirements: 1) an abundance of ungulate and alternative prey species, and 2) isolation from human disturbance. Wolves will take a variety of prey species, but the bulk of their prey (over 90 percent by weight) is composed of ungulates, mainly deer, elk, and moose (USFWS, 1987). Also, wolves are sensitive to human disturbance, particularly near their denning and rendezvous sites. Factors such as road density have been shown to be important indices of levels of disturbance that wolves can tolerate (Mladenoff et al., 1995).

In 1995, a non-essential, experimental population of gray wolves was reintroduced in the rugged, mountainous terrain of central Idaho. The status of this population allows individuals to be managed in such as way as to avoid conflicts with land uses outside the designated introduction area (USFWS, 1994b). This initial population consisted of 35 adult wolves, which were released in three different locations in the central Idaho wilderness. According to the latest update from the Snake River Basin Office of the USFWS, which is based on wolf locations obtained during aerial surveys between October 2 and 21, 1998, this initial population has reproduced successfully.

There are now 12 known wolf packs in central Idaho, of which 10 successfully reproduced in 1998 (USFWS, 1998c). The total number of wolves in Idaho related to the reintroduction effort, based on radio telemetry and visual documentation, is estimated at 122. The number of wolves in the state could be slightly larger due to transient and dispersing wolves from Canada and Montana. These results are significant for the wolf recovery effort because it is the first year Idaho has met its recovery goal of maintaining 10 breeding packs for 3 consecutive years.

The closest known wolf activity to the study area is in the headwaters of the North Fork of the Clearwater River and along the Salmon River south of Elk City, Idaho, which are both approximately 100 miles from Lewiston, Idaho. As recently as February 1999, a lone female gray wolf dispersed from central Idaho into eastern Oregon, a distance of some 200 miles. This included crossing the Snake River. There have been no sightings of wolves closer to the study area, but given that lone wolves can have home ranges of more than 1,000 square miles (USFWS, 1987), it is conceivable that they could occur in the study area. However, this is unlikely given the relatively high level of human activity and high road density in the study area.

Grizzly Bear

Grizzly bears have three main habitat requirements: 1) a wide range of high-energy foods during all seasons, including both herbaceous and animal sources; 2) dense forest cover; and 3) suitable denning locations in remote, steep areas away from human disturbance (USFWS, 1993). Grizzly bear movements are primarily influenced by the annual availability of food. They tend to move to lower elevations early in the year and move to higher elevations as herbaceous food sources are available (USFWS, 1993).

The grizzly bear persists in very low numbers in Idaho. Two small populations persist in the Selkirk and Cabinet/Yaak ecosystems of extreme northern Idaho. The USFWS observed only one female bear with cubs of the year in 1997 in the Selkirks, and three females with cubs in 1997 in the Cabinet/Yaak area. Also, bears will wander into Idaho from Yellowstone National Park. All of these areas are at least 150 miles from the study area.

Historically, grizzly bears were abundant in the drainage of the Clearwater River and into the Selway-Bitteroot Mountains up to the turn of the century (USFWS, 1998b). However, hunting, trapping, predator control, and the decline of anadromous fish runs lead to the virtual extinction of the grizzly in central Idaho by the 1950s. The last confirmed grizzly bear occurrences were of individuals killed in the Bitterroot Mountains in 1932 (Moore 1984, 1996).

The wilderness areas of central Idaho (Frank Church River of No Return, Selway-Bitterroot, and Gospel Hump) are being considered by the USFWS as one of six recovery zones identified in the Grizzly Bear Recovery Plan (USFWS, 1993) which could potentially support viable populations of the bear. The USFWS is currently in the process of reviewing and incorporating public comments on the draft Bitterroot Grizzly Bear EIS that analyzes in detail the existing conditions and potential impacts of reintroducing grizzly bears to the Bitterroot Ecosystem. The Selway-Bitterroot Wilderness is approximately 100 miles (to Lewiston, Idaho) from the study area. If bears were reintroduced into this wilderness, it is conceivable that they could occur in the study area given that grizzly bears will range over wide areas. However, it is unlikely that they would occur in the study area given the high level of human activity and the lack of suitable food resources.

Canada Lynx

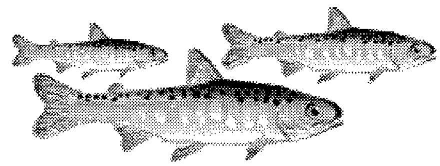
The Canada lynx was proposed for listing under the ESA on July 8, 1998 (50 CFR Part 17, Federal Register 63:130, 36993-37013). Its status is currently under review, and a final decision on its listing is expected to be made in January 2000.

In the West, verified occurrences of lynx have been reported from Washington, Oregon, Montana, Idaho, Wyoming, Colorado, Utah, and Nevada (McKelvey et al., 1999a, draft). Over 130 verified records of lynx exist in Washington, most of them from the north Cascades, Okanagan Highlands, and northeastern corner of the state (McKelvey et al., 1999a, draft). However, records for Washington do exist from the central and southern Cascades and in the Blue Mountains (Koehler and Aubry, 1994). Currently, the range of the lynx in Washington is considered to include most of these areas, with the exception of the Blue Mountains. The USFWS has concluded that a resident lynx population exists in Washington (USFWS, 1998d). The WDFW has estimated the current lynx population in the State of Washington at between 100 and 200 individuals (WDFW, 1993).

The distribution and abundance of the Canada Lynx is closely tied to that of its primary prey, the snowshoe hare. However, it is widely accepted that lynx population levels in Washington (and other areas in the southern limits of the lynx range) do not fluctuate as compared to populations in Canada because snowshoe hare cycles are not as pronounced in southern latitudes (Koehler and Aubry, 1994; Koehler, 1990; McKelvey et al., 1999b). Studies by McKelvey et al. (1999b, draft) from north-central Washington indicate that lynx are strongly associated with logdepole pine stands on north-facing aspects between 1,400 and 2,150 meters in elevation. These authors found that this pattern of habitat use by lynx also corresponds to habitat types with the greatest abundance of snowshoe hare. Other habitat variables that are important to lynx include dense, mature conifer forest with large woody debris suitable for denning, and travel corridors between populations. These corridors can be a variety of habitat types, but are usually some type of dense deciduous or conifer stands (Koehler and Aubry, 1994).

The major threats to this species are continued large-scale fragmentation of suitable conifer forest habitat due to timber harvest and development, trapping (which is not allowed in Washington), and interspecific competition, particularly from coyote, bobcat, and cougar (Koehler and Aubry, 1994; USFWS, 1998a; Buskirk et al., 1999).

No suitable habitat for this species exists in the study area. It is very unlikely that this species would occur in the study area, but recent observation from the Blue Mountains of Oregon (USFWS, 1998d) and historic records from Idaho demonstrate that transient lynx could pass through the study area.



4.7 Cultural Resources

Cultural resources in the Snake River Basin are a rich source of information about prehistoric and historic human use and occupation of the study area dating back over 11,000 years. Cultural and historic resources can be generally categorized into one of the following three groups: historic sites, prehistoric archaeological sites, and traditional cultural properties. The information provided in this section is primarily derived from Technical Appendix N, Cultural Resources, and Appendix D of the SOR FEIS (BPA et al., 1995).

4.7.1 Cultural Resource Definition

Known cultural resources in the Snake River Basin consist of traditional cultural properties, as identified by affected Native Americans, as well as archaeological sites. Other cultural resources include the remains of historic settlement and development activities of Euro-Americans, Asians, and other non-Native cultures over the past 200 years. Federal agency responsibilities concerning cultural resources are defined in law, primarily by the National Historic Preservation Act (NHPA), Archaeological Resources Protection Act (ARPA), Native American Graves Protection and Repatriation Act (NAGPRA) and American Indian Religious Freedom Act (AIRFA).

Prehistoric archaeological sites are typically represented by open campsites; pit house (a semi-subterranean dwelling) villages; rockshelters; rock art (petroglyphs/pictographs); lithic (stone) quarries and workshops; burial grounds and cemeteries; and isolated rock cairns, pits, and alignments. Historical sites are denoted by structures, buildings, and objects that represent activity influenced by Euro-Americans. These include the remains of farms, towns, trading posts, mining sites, military forts, burial sites, abandoned settlements, and transportation and industrial facilities.

Contemporary Native Americans recognize archaeological sites as important resources, but also emphasize their interests in traditional cultural properties. Traditional cultural properties, as a class of cultural resources, may include a broad range of features from

the natural environment and sacred world. Traditional cultural properties are places and resources composed of both cultural sites and natural elements significant in contemporary traditional social and religious practices, which often help preserve traditional cultural identities. For example, certain distinctive shapes in the natural landscape, features in a tribe's cultural geography, habitats for culturally significant food and medicinal plants, traditional fisheries, sacred religious sites and places of spiritual renewal may constitute traditional cultural properties. Some tribes assert that the Snake River itself is a traditional cultural property. The following discussion of cultural resources focuses on tangible resources such as sites and artifacts. Native American values are discussed in Section 4.8, Native American Indians, and Section 5.7, Native American Indians.

4.7.2 Cultural Resource Significance

The significance of a historic property is defined in the NHPA and is based upon a site's eligibility for the National Register of Historic Places (NRHP). Under Section 106 of the NHPA, Federal agencies are required to take into account the effects of their undertakings on all historic properties included in or eligible for the NRHP (i.e., "significant" historic properties). Eligibility criteria for listing on the NRHP relates to the quality of preservation of a site and its contents, location, integrity of setting and materials, and association with particular ethnic groups or historically known individuals and events. Except under rare circumstances, a property must be at least 50 years old to be eligible for nomination to the NRHP.

A particular site's setting and/or contents are essential to scientists' efforts to examine research questions about the past. Common research themes include cultural history, cultural process, and human adaptations in response to environmental change. Certain cultural sites are significant because they may represent a specific time period. Marmes Rockshelter on Lower Monumental Reservoir and Windust Caves on Ice Harbor Reservoir are examples of significant sites that contain evidence of some of the earliest human occupants in the lower Snake River canyon. These occupants are believed to have lived between 9,800 and 10,200 years ago.

Many archaeological sites are points of recreational or educational interest for the public through interpretation of their historical and scientific significance. Archaeological sites are also important to the heritage of regional Native American groups, whose primary interest lies with protection rather than investigation.

4.7.3 Prehistory

During the earliest period of human occupation, over 8,000 years before present (BP), people in the general region of the Lower Snake River Project are believed to have foraged for a wide variety of food resources located in different topographic zones. The time between 8,000 and 4,000 years BP witnessed a warming trend and a shift toward more use of plant foods and aquatic resources including salmon and freshwater clams. From 4,500 to 2,500 years BP, people residing in the study area developed pit house villages and further intensified their use of plant and aquatic foods (e.g., river clams). From 2,500 to 250 years BP, the number of pit house village sites expanded further as did the use of salmon and plant foods. The bow and arrow was also introduced during this time. The last 250 years coincide with the historic and ethnographic period from the

acquisition of the horse by native peoples in the early Eighteenth Century to their displacement to reservations in the late Nineteenth Century, and the settling of the area by Euro-Americans.

At the time the Euro-Americans arrived in the Pacific Northwest, they found numerous Native American groups living throughout the Columbia River Basin. The large geographic distribution and the diversity of dialects represented in the languages are evidence for the long presence of native peoples in the region. The lower Snake River was occupied by numerous bands of Native Americans who spoke dialects of the Cayuse, Northeast Sahaptin, and Nez Perce languages. Political organizations consisted of loosely associated villages of family groups, each village with its own general territory and leadership. While these bands were fairly distinctive, they shared similar customs and languages, and jointly used major subsistence and trade markets. Native bands also formed a larger southern Plateau Culture Area society through economic and political alliances.

Middle Columbia and lower Snake River bands shared subsistence-based economies supported by hunting, fishing, and foraging. These practices required families to make annual seasonal migrations throughout their homelands and to places elsewhere within the region. People harvested foods as they became ready and participated in a trade network involving other bands. It is estimated that as much as one-third of the southern Plateau Area peoples' annual diet may have come from aquatic resources such as salmonid fish species. Food plants may have supplied an additional 50 percent of their annual food supply, with game and huckleberries making up much of the remaining amount (Hunn, 1990).

4.7.4 Historic Period

European and American influence began in the early 1700s when European trade items were transported into the Snake River Basin by Native American traders. The first contact between Euro-Americans and Native Americans in the region occurred in 1805 with the arrival of the Lewis and Clark Corps of Discovery. The Lewis and Clark Corps of Discovery followed the course of the lower Snake River, traveling through the homelands of the Nez Perce, Palus, Cayuse, and Walla Walla tribes/bands (Coues, 1893). The Lewis and Clark expedition was followed by other expeditions, that further explored the region and established trading operations. Missionaries arrived in the 1830s, soon to be followed in the 1840s by increasing numbers of settlers coming west.

In 1855, treaties establishing area reservations were signed between the United States and many of the Plateau Culture Area tribes/bands. Gold was discovered in Idaho in the 1860s, leading to a rush of settlers into the area. Further settlement was based on extensive dryland wheat farming. This was the era of the steamboat. Between 1855 and 1880, conflicts arose between non-Native American settlers and local tribes, resulting in several wars. Federally recognized tribes were required to relinquish part of their homelands. However, through treaty negotiations, these tribes legally retained certain pre-existing rights that allow them to fish at usual and accustomed areas, and hunt, gather, and graze livestock on open and unclaimed lands.

The 1880s brought construction of railroads and continued settlement. The 1900s have seen the damming of the Snake River, the development of major irrigation projects, and continued growth in the region.

4.7.5 Identified Historic and Archaeological Sites

There are approximately 375 known archaeological sites within the four reservoirs of the Lower Snake River Project, some of which are partially or completely inundated. The known sites are both prehistoric and historic and range in age from the earliest period of human occupation to recent times. Identified prehistoric sites include villages, fishing sites, burials, rock art (pictographs and petroglyphs), storage pits, and temporary camps. Historic sites include homesteads, mining sites, forts, towns, and trading posts.

Two archaeological districts (Windust Caves and Palouse Canyon) and three sites (Marmes Rockshelter, Burr Cave, and Hasotino) are listed on the NRHP. In addition to NRHP status, Marmes Rockshelter is also a designated National Historic Landmark. The Marmes Rockshelter and the Palouse Canyon Archaeological District are both located within the Lower Monumental Reservoir. The Windust Caves Archaeological District/Burr Cave and the Hasotino site are located within by the Ice Harbor and Lower Granite reservoirs, respectively. Many other cultural resources at the reservoirs are potentially eligible for NRHP nomination, but have not been thoroughly evaluated or nominated.

In summary, the NRHP sites and districts at the four lower Snake River reservoirs include:

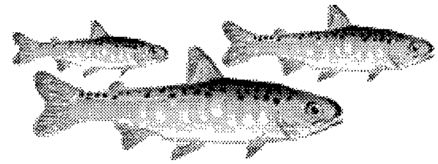
Ice Harbor Dam, Lake Sacajawea
- Windust Cave Archaeological District (listed)
- Burr Cave (listed)

Lower Monumental Dam, Lake West
- Palouse Canyon Archaeological District (listed)
- Marmes Rockshelter (National Historic Landmark)

Little Goose Dam, Lake Bryan
- No sites currently listed or determined eligible

Lower Granite Dam, Lower Granite Lake
- Hasotino Archaeological Site (listed)
- Archaeological sites 45-WT-78/79 (determined eligible)

Most scientific information generated about cultural resources found in the Snake River System has been the result of archaeological studies associated with the construction of Federal dams in the study area. A comprehensive survey has only been done for the Ice Harbor reservoir and evaluation of all known sites has not been accomplished at any of the four reservoirs in this study. Survey/evaluation methods and standards have changed considerably since the dams were constructed, so there is still much that is unknown about cultural resources in the reservoir pools. The Corps routinely works with Native American Indian tribes and others to inventory and manage cultural resources found in the study area.



4.8 Native American Indians

This section discusses the Native American Indian tribes and bands whose interests and/or rights may be affected by the proposed Federal actions in the FR/EIS. This discussion includes the following tribes and bands:

- Confederated Tribes of the Colville Indian Reservation
- Confederated Tribes of the Umatilla Indian Reservation
- Confederated Tribes and Bands of the Yakama Nation
- Nez Perce Tribe
- Wanapum Band
- Burns Paiute Tribe
- Coeur d'Alene Tribe
- Confederated Tribes of the Warm Springs Reservation of Oregon
- Kalispel Indian Community of the Kalispel Reservation
- Kootenai Tribe of Idaho
- Northwestern Band of the Shoshoni Nation
- Shoshone-Bannock Tribes of the Fort Hall Reservation
- Shoshone-Paiute Tribes of the Duck Valley Reservation
- The Spokane Tribe of the Spokane Reservation.

This section pulls information from a number of sources. One specific source of tribal information is the Tribal Circumstances and Perspectives report (Meyer Resources, 1999) prepared by a contractor in association with the Columbia River Intertribal Fish Commission (CRITFC). The Tribal Circumstances and Perspectives report focuses on input from specific tribes and sets forth their perspective. The five tribes which

participated are the Nez Perce Tribe (Nez Perce), the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), the Yakama Nation (Yakama), the Confederated Tribes of the Warm Springs of Oregon (Warm Springs) and the Shoshone-Bannock Tribes of the Fort Hall Reservation (Shoshone-Bannock). These five tribes were selected for specific input because of their close cultural linkages, blood ties, pursuit of salmon and other similar food resources, languages, and similarity of treaties. Although the Tribal Circumstances and Perspectives report cited throughout this section refers specifically to these five tribes, it is assumed that some of the more general issues detailed in this report would be applicable, in various degrees, to the other nine regional tribes listed above.

4.8.1 Overview

Native cultures within this region developed over thousands of years. By the early 19th century, these cultures had developed numerous different languages and dialects, and a variety of effective life ways for living in the unique environments of the Pacific Northwest. A variety of significant natural resources and habitats such as riverine, lake, or other aquatic environments supported their subsistence-based economies. These subsistence-based economies were in turn bolstered by established trade, political and social networks, and alliances that served to connect the region's different cultures. In these societies, villages harvested local resources and hosted inter-band resource/trade centers in their own lands through mutually beneficial agreements and concepts of exchange.

The formation of Federally recognized tribes in the mid-19th century placed these different cultures together on reservation lands often located outside of a band's homeland. Those families that chose to remain within their homelands often did so by opting to acquire Indian allotments or, in a few cases, by remaining in villages with eventual Federal government acceptance. Traditional cultural practices such as harvesting foods and medicines, observing native religions and ceremonies, speaking native language dialects, and living in extended families continued throughout the 19th and 20th centuries, although in increasingly fragmented forms as people became acculturated and communities adapted to local American lifestyles.

Reservation communities continue to be the predominate place of residence for the descendants of lower Snake River native peoples. Their tribal governments remain their primary form of representation in family and community life, even though local and state governments share responsibilities to these citizens. As part of agreements made when the tribes ceded lands to the U.S. Government, tribes typically retained rights to hunt, fish and gather, and to graze livestock. In addition, tribes and American Indian communities maintain cultural values in both natural and cultural resources managed by the Corps in the lower Snake River. Numerous aquatic, plant, and wildlife species retain cultural significance to tribes (e.g., salmonids, lamprey, sturgeon, whitefish, sculpin, deer, cous, Indian carrots, chokecherries, and tules).

4.8.1.1 Tribal Summaries

This section provides an overview of the 14 potentially affected tribes.

Burns Paiute Tribe of the Burns Paiute Indian Colony

Members of the Walpapi Band of the Northern Paiute signed the Treaty with the "Snake" band in 1865. The tribe signed a treaty with the U.S. Government in December 1868; Congress failed to ratify it. The Executive Order of March 1872 established the Malheur Indian Reservation and recognized the Burns Paiute Indians. However, in 1883 another Executive Order dissolved the reservation and the tribe lost Federal recognition. The 1.8-million-acre Malheur Indian Reservation was terminated and the land was made public domain. The 1887 Indian Allotment Act allowed for 160 acres to each tribal head of household. The Burns Paiute Tribe is located in eastern Harney County, Oregon. Tribal Headquarters are in Burns, Oregon. In 1972, the United States transferred title to 762 acres to the Burns Paiute and established the Burns Paiute Reservation through Public Law 92-488.

The current reservation consists of 771 acres, and another 11,786 acres of allotments are owned by tribal members. An additional 360 acres are held in trust and administered for the tribe by the Bureau of Indian Affairs. The tribe is self-governing. A Tribal Council of seven elected members was established by the tribe in 1988.

The peoples represented by the tribe are of the Great Basin Cultural Region consisting of the northern division of the Paiute peoples. The original homeland of the Northern Paiute peoples included southeast Oregon, most of northwestern Nevada, and a portion of southwest Idaho. Northern Paiute associated with the Burns Indian Reservation include the remnants of the Wadaika band (Wada Eaters who historically were centered around Malheur and Harney lakes); the Hunipui (Juniper-Deer Eaters of the Crooked River area); the Walpapi (Elk Eaters of the upper John Day River area); the Tagu (Salmon Eaters of the Owyhee River area); the Kidu (Groundhog Eaters of the Fort Bidwell area); and the Koa'agai. Northern Paiute and English are spoken by the tribe. Major religious affiliations include traditional Indian religions and denominations of Christianity.

Coeur d'Alene Tribe

In 1867, an entity called the Coeur d'Alene Reservation was created for the Coeur d'Alene, Kalispel, Spokane, Sanpoil, and Colville "bands." The Coeur d'Alene never moved to that reservation. In 1873, a 592,000-acre reservation was created for the Coeur d'Alene Tribe by Executive Order. In following years, the reservation area was reduced, lands ceded, and portions removed from the reservation. Today's reservation consists of 345,000 acres in northern Idaho.

Tribal government is under a constitution originally approved on September 2, 1949. The Tribal Council is the legislative body. Tribal Headquarters are in Plummer, Idaho.

Peoples represented by the tribe are of the Plateau Cultural Region and are of the Coeur d'Alene, Spokane, and San Joe River Tribes and Bands. In 1842, a Catholic mission was established by Father Pierre DeSmet near St. Maries for the tribe. Today, religious affiliations include traditional Indian religions and denominations of Christianity. Interior Salish and English are spoken by the tribal peoples.

Confederated Tribes of the Colville Indian Reservation

The basis for formal Federal recognition of the tribe and recognition of the inherent sovereignty was established through the "Nez Perce" and "Yakama" Treaties of June 9, 1855. The Executive Order of April 9, 1872—which was superseded by Executive Orders of March 6, 1879, February 23, 1883, March 6, 1880, and May 1, 1886; Agreements of May 9, 1891, July 1, 1892, December 1, 1905, and March 22, 1906; and the Act of June 20, 1940—all helped refine the Colville Tribe's relationship with the U.S. Government.

The Colville Reservation was established on April 9, 1872 in north-central Washington. Modifications to the reservation size, status, and location in later years resulted in the present 1.4-million-acre reservation in north-central Washington. The basis of the tribe's off-reservation rights and interest is derived from the Yakama and Nez Perce Treaties of 1855, Article 3 and a 1891 Agreement, Article 6. It is through the Yakama Treaty that members of the Palus band moved onto the Colville Reservation in the late 19^{th} century. The Colville tribe asserts rights and interests in ceded lands of the Palus people along the lower Snake River.

The Colville Tribe did not adopt the Indian Reorganization Act of 1934, but did establish a constitutional form of government with a Business Council since 1938. The tribe's Business Council membership is elected from four reservation districts comprised of two groups of seven council members that are elected to four-year terms in staggered biennial elections. The chair and vice-chair Business Council positions are filled through elections held by its Executive Committee, while all other positions are elected by the entire Business Council membership. The General Council meets bi-annually to provide direction to the Business Council. The Colville Tribes have operated under a tribal self-determination agreement with the Bureau of Indian Affairs since 1995 that has integrated BIA staff positions with the tribe's. Colville Tribal Headquarters are located in Nespelem, Washington.

The Confederated Tribes of the Colville Indian Reservation (CTCIR) represent peoples of the Plateau Culture Area including the Methow, Sanpoil, Lakes, Colville (Sweelpoo), Kalispel, Spokane, Entait, Nespelem, Chelan, Columbia (Senkaiuse), Chief Joseph Band of the Nez Perce (Nimiipu), Wenatchee (Wenatchapum), Southern Okanogan (Sinkaietk), Palus, and Lakes (Senijextee). Interior Salish, Sahaptin, and English are spoken by the tribal population. Religious affiliations include traditional Indian religions, and denominations of Christianity.

Confederated Tribes of the Umatilla Reservation

The "Treaty with the Walla Walla, Cayuse, and Umatilla Tribes," subsequent Treaties, and the CTUIR Constitution form the basis for formal recognition of the tribes' inherent sovereignty. The tribal government's off-reservation treaty rights are recognized in Article 1 of the treaty. Congress ratified this treaty in 1859 and a reservation was established encompassing 254,699 acres in what has become northeastern Oregon. The size of the reservation was reduced through subsequent congressional acts and today consists of 89,350 acres of trust and allotted lands. The tribes rejected the Indian Reorganization Act in 1935 by tribal referendum. However, a Constitution and By-laws were adopted in 1949. The tribal governing body consists of a General Council and a Board of Trustees (BOT). The BOT is a nine-member council that sets tribal policy and makes final tribal decisions. The BOT members are elected together in a single election

for 2-year terms. All BOT members, except the chairperson, participate in tribal commissions and committees and thereby oversee tribal business. Tribal headquarters are in Mission, Oregon.

The bands represented by the CTUIR were affiliated with the southern Plateau Culture Area. English, Sahaptin dialects, and the Nez Perce language are spoken by tribal citizens. Major religious affiliations include traditional Indian religions and Christian denominations.

Confederated Tribes of the Warm Springs Reservation of Oregon

In 1855, the sovereignty of the Confederated Tribes of the Warm Springs Reservation was recognized in the "Treaty with the Tribes of Middle Oregon." (The "Treaty with the Tribes of Middle Oregon of 1865" was later negated by the U.S. Government.) Today's reservation, in central Oregon, consists of 640,000 acres, 480,196 acres of which are tribal-owned.

The tribes adopted the Indian Reorganization Act in 1935 and adopted a Constitution and By-laws in 1938. The tribes have an elected Tribal Council and various tribal committees and boards. The tribes are self-governing. Tribal Headquarters are in Warm Springs, Oregon.

Peoples represented on the Reservation are of Plateau and Great Basin Cultural Regions and are from the Wasco Bands—Dalles, Ki-gal-twal-la, and Dog River; Warm Springs—Taih or Upper Deshutes, Wyam (Lower Deshutes), Tenino, Dock-Spus (John Day River); and Northern Paiutes (Removed to Warm Springs Reservation in the 1880s) groups. Languages spoken by tribal members include English, Chinookan, Sahaptin, and Shoshonean (Northern Paiute). Major religious affiliations include traditional Indian religions, traditional belief systems, and Christian denominations.

Confederated Tribes and Bands of the Yakama Nation

In 1855, the "Yakama Treaty" established the Yakama Nation and a reservation in what is now south-central Washington. Pre-treaty lands included about a quarter of the modern State of Washington. Other binding treaty documents include the Agreement of January 13, 1885, Executive Order November 21, 1892; and Executive Order 11670. A number of land ownership changes have resulted in the current 1.2-million-acre reservation. As a point of interest, the spelling of Yakama was changed from Yak[i]ma back to the original spelling in the Treaty of 1855 by a vote of the Tribal Council on January 24, 1994. In 1999, the tribal government also indicated a preference to be known as the Yakama Nation.

The Tribal Council is the governing body and is comprised of 14 members. The General Council elects Tribal Council members in elections held every 2 years wherein half of the Tribal Council is elected to 4-year terms. The tribe's democratic government is regulated by General Council and Tribal Council resolutions. The tribe rejected the Indian Reorganization Act in 1935. The Tribe has a self-determination form of government and operates under traditional laws, ordinances, and resolutions as opposed to having a constitution. The Tribal Council oversees tribal business through eight standing committees and seven special committees. The General Council meets annually

for an extended period of time to provide direction to the Tribal Council. The Tribal Headquarters are in Toppenish, Washington.

The 14 bands represented on the Reservation include the Klickitat, Klinquit, Li-ay-was, Kow-was-say-ee, Oche-chotes, Palus, Shyiks, Pisquose, Se-ap-cat, Skinpah, Wishram, Wenatshpam, Yakama, and Kah-milt-pah. These are all peoples of the southern Plateau Cultural Area. Religious affiliations include traditional Indian religions and belief systems, and denominations of Christianity. Languages spoken on the reservation include English, and numerous dialects of Sahaptin, Chinookan, and Salish.

Kalispel Indian Community of the Kalispel Reservation

The tribe's inherent sovereignty was recognized through an agreement with about half of the Kalispel tribe in an Executive Order dated April 21, 1887. In 1904, another Executive Order established a reservation for the tribe. However, the U.S. Government wanted to move the Kalispel to the Flathead Reservation. A second 4,630-acre reservation was established in northeastern Washington on March 23, 1914. Today, the reservation is about 4,550 acres. A Tribal Constitution and Charter was originally adopted on March 24, 1938. In addition to the Constitution, Tribal Council resolutions create tribal law. The Tribal Headquarters are in Usk, Washington.

Peoples from tribes and bands of the "People of the Pend Oreille" are represented on the Reservation. These peoples are of the Plateau Cultural Region. Major religious affiliations include Christian denominations, primarily Catholic. English and Interior Salish dialects are spoken.

Kootenai Tribe of Idaho

The Treaty with the Flathead, Kootenai, and Upper Pend d'Oreilles of July 16, 1855 established the tribe's sovereignty. Some Kootenai living in the vicinity of the Canadian border did not move to the reservation when the Flathead Reservation in Montana was established. A group of Kootenai families living near Bonners Ferry were recognized by the U.S. Government in 1894. By 1972, a reservation existed of approximately 2,683 acres. Today's reservation is approximately 1,300 acres. The tribe adopted a Constitution in 1947. A revision of the Constitution has been proposed. In addition to the Constitution, the tribe is regulated by a code of conduct. Tribal Headquarters are in Bonners Ferry, Idaho.

The Kootenai peoples were composed of two groups: Upper and Lower. Two of the three bands of Lower Kootenai now reside in Canada. Major religions followed by the tribe include denominations of Christianity and traditional belief systems. Languages spoken are English and Kitunahan dialects.

Nez Perce Tribe

The "Nez Perce Treaty" of June 11, 1855 and subsequent treaties, acts, agreements, and proclamations established the legal status of the Nez Perce Tribe. A reservation of 7.7 million acres was established in 1855. In 1863, the reservation was re-established with 780,000 acres. The present reservation is 750,000 acres between the Clearwater and Snake rivers in Idaho. The tribe rejected the Indian Reorganization Act in 1935 by tribal referendum. A Constitution and By-laws were originally adopted in 1927. The tribe is

self-governing under a Constitution, which was adopted in 1958 and revised in 1961. The Nez Perce Tribe Executive Council (NPTEC) is the tribe's primary governing authority and they meet formally twice a month. The tribe's governing body (composed of tribal membership) is the general council and they meet twice a year. The general council elects three of the nine NPTEC members every year in September. There is no provision under the Nez Perce Council to hold special General Council meetings. Tribal Headquarters is in Lapwai, Idaho.

People represented by the tribal government are of the tribe and bands of the Nez Perce People (Nimiipu) and are associated with the southern Plateau Culture Area. Major religious affiliations include Christian denominations, traditional Indian religions and belief systems. English and Sahaptin Nez Perce language dialects are spoken. A Nez Perce newspaper is published by the tribe.

Northwestern Band of the Shoshoni Nation

Legal status is based on the Treaty of Box Elder of June 30, 1863 and subsequent Acts and Agreements. By 1900, many of the Northwestern Band resided on the Fort Hall Reservation. Others reside in Utah and Idaho communities. In 1989, the Tribe acquired 187 acres of land that constitutes the present Reservation in north-central Utah. Other nearby land parcels are held in trust by the Bureau of Indian Affairs. A Constitution was approved on August 24, 1987. They did not accept the Indian Reorganization Act of 1934. The tribe is self-governing with a General Council of all adult enrolled tribal members and an elected Tribal Council. Tribal headquarters are in Brigham, Utah.

The Northwestern Band of Shoshoni include the Weber Utes, Northwestern Shoshoni, and other Shoshoni people from the Lemhi area of southeastern Idaho. Traditional religions and denominations of Christianity are the major religious affiliations. Shoshone and English are spoken.

Shoshone-Bannock Tribes of the Fort Hall Reservation

The Treaty with the Eastern Shoshoni Tribe of 1863 and subsequent Treaties, Acts, and Agreements form the basis for the sovereignty of the Tribes. The Treaty reservation was originally established at 1.8 million acres. The present Reservation is comprised of 544,000 acres in southeast Idaho adjacent to Caribou National Forest. The tribal governments for the Shoshone and Bannock peoples operate under a Constitution and By-laws adopted in 1977, the Land Use Ordinance, the Big Game Code, the Law and Order Code, inherent sovereignty, customs, and traditions. The legislative body is the elected Fort Hall Business Council.

The Shoshone-Bannock tribes compose one Federally recognized tribe that includes two distinct groups—the Northern or Snake River Shoshone, and the Bannocks. The four Northern Shoshone Band divisions include the Western Shoshone (Warraeekas) including the Boise and Bruneas; the Mountain Lemhi Shoshone including the Tukuerukas (Sheepeaters) and the Agaidikas (Salmon Eaters); the Northwestern Shoshone including the Bear Lakes, Cache Valley, Bannock Creek, and Weber Ute; and the Pohogue (Fort Hall) Shoshone. Major religious affiliations include Christian denominations, the Native American Church, and traditional beliefs. Languages spoken include English, Shoshone, Bannock, and other dialects.

Shoshone-Paiute Tribes of Duck Valley Reservation

The Executive Order of April 16, 1877 set aside the Duck Valley Reservation for several Western Shoshoni bands that traditionally lived along the Owyhee River of southeastern Oregon, southwestern Idaho, and the Humbolt River of northeastern Nevada. Later, Paiute from the lower Weiser country of Idaho and other Northern Paiute families joined the Shoshoni on the reservation. The reservation was expanded in 1886 to 500,000 acres to include a Northern Paiute group (Paddy Cap's Band), who arrived in 1884 following their release from the Yakama Reservation. The current reservation is 294,242 acres. The entire reservation is owned by the tribe, forming a contiguous block of property located partially in southern Idaho and northern Nevada.

The tribe adopted a Constitution in 1936 in conformance with the Indian Reorganization Act of 1934. The tribe is one of the original 17 tribes that achieved a self-governing status having shed Bureau of Indian Affair's supervision. The tribe has General Council meetings of adult tribal members and a six-member elected Tribal Council. Tribal Headquarters are in Owyhee, Nevada.

Western Shoshone and Northern Paiute peoples are represented on the Reservation. Traditional religious beliefs and Christian denominations form the tribe's primary religious affiliations.

The Spokane Tribe of the Spokane Reservation

The Executive Order of January 18, 1881 and subsequent Agreements and Acts form the basis for the tribe's sovereignty. The first reservation was also established in 1881 in northeast Washington. Today the reservation is comprised of 137,002 acres of fee, allotted, and trust lands. The tribe approved a Constitution in May 1951, establishing a Business Council. Today, a general election chooses a five-member General Council which then elects members to the Business Council. At least once a year adult tribal members meet to advise the General Council. The tribe is self governing. Tribal headquarters are in Wellpinit, Washington.

Peoples represented by the tribe are of the Northern Plateau and represent Upper Spokane (Snxwemi'ne: people of the steelhead trout place); Middle Spokane (Sqasi'lni: fishers, after a village name); Lower Spokane (Sineka'lt: rapids, after a village name); and Chewelah groups. Major religious affiliations are Christian denominations, primarily Catholic. English and Interior Salish are spoken by the tribe.

Wanapum Band

The Wanapum Band today is a traditional Indian community that lives along the middle Columbia River within their native homeland. The community is comprised of a longhouse and families that follow traditional social, subsistence and religious customs while having adapted to modern societal, and economic demands. The Wanapum people believe that their Creator gave them the land as a sacred trust and would not take it away from them. The families who live at Priests Rapids maintain the responsibility to address concerns on their ancestral homeland. The Wanapum have never left their homeland because of the sacred trust, and their responsibilities as they have been handed down to them from their elders.

4.8.2 Tribal Resources

Tribes and traditional Indian communities continue to have rights and interests in the lands and resources managed by the Federal government. For example, tribal rights and interests relate to lands a tribe ceded to the U.S. Government and regard certain rights to hunt, fish and gather, and graze livestock. In addition, tribes maintain cultural values in both natural and cultural resources located in the lower Snake River. Numerous aquatic, plant and wildlife species retain cultural significance to tribes (e.g., salmonids, lamprey, sturgeon, whitefish, sculpin, deer, cous, Indian carrots, chokecherries, and tules). Land and salmon are discussed below. For additional information concerning the tribal view of natural and cultural resources, see Technical Appendix N, Cultural Resources, Technical Appendix Q, Tribal Consultation/Coordination, and the Tribal Circumstances and Perspectives report (Meyer Resources, 1999).

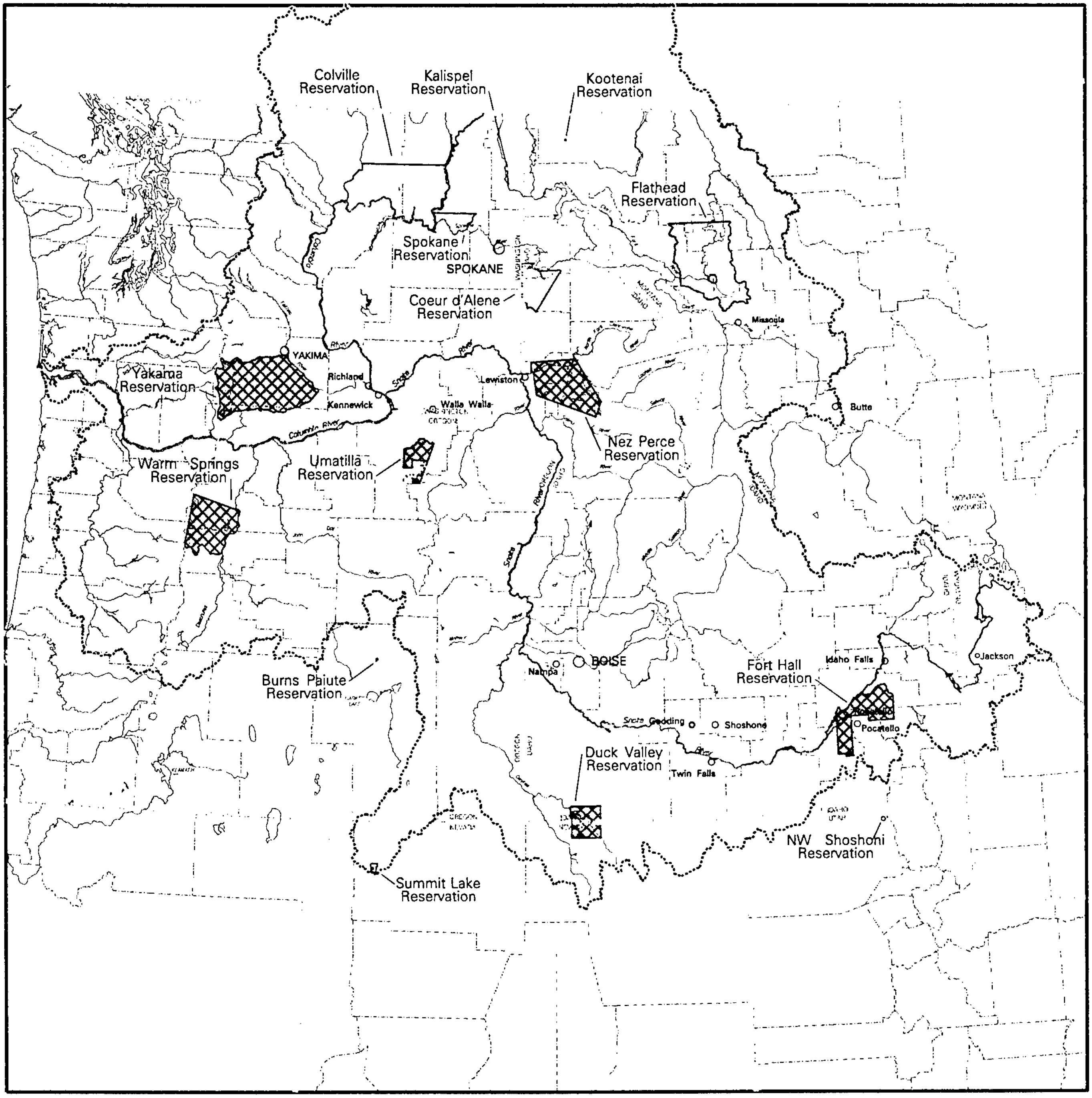
4.8.2.1 Land

As indicated in Section 4.8.1.1, Tribal Summaries, the tribes of this area historically retained more land than they currently own. Current reservation locations and approximate boundaries are marked on Figure 4.8-1. This FR/EIS does not enter the debate concerning historical land transfers except to the extent needed to determine the direct, indirect, and cumulative impacts to the tribes from the alternatives being studied in this FR/EIS. Summary data regarding the present day reservations of the five tribes addressed in the Tribal Circumstances and Perspectives report are provided in Table 4.8-1. Details on the land purchased by the Corps to build the dams and disposal options are described in Technical Appendix K, Real Estate, and summarized in Section 5.11. Tribal perspectives are provided in the Tribal Circumstances and Perspectives report (Meyer Resources, 1999) and summarized in the tribal section of Technical Appendix I, Economics.

Table 4.8-1. Study Tribe Reservations and Enrolled Populations

Tribes	Reservation	Total Acres	Indian-Owned Acres	Non-tribal Owned Acres	Tribal Enrollment
Nez Perce	Nez Perce	na	108,000	na	3,000
Shoshone-Bannock	Fort Hall	544,000	1/	1/	3,700
Shoshone-Paiute	Duck Valley	293,700	2/	2/	1,003
Yakama Nation	Yakama Indian Reservation	1,379,725	1,126,445	253,280	9,601
Umatilla	Umatilla Indian Reservation	292,744	95,136	197,608	2,087
Warm Springs	Warm Springs	643,000	641,110	2,102	1,683 3/

1/About 3 percent of the reservation is owned fee simple by Indians. No other data is currently available.
2/Nearly all reservation lands are owned by Indians. No other data are currently available.
3/This is the 1972 population total. No other data are provided in the Tribal Circumstances and Perspectives report.
na - not currently available
Source: Meyer Resources, 1999.



BOUNDARIES

Columbia River Basin

State

County

TRIBAL RESERVATIONS

Study Tribes

Other Basin Tribes

KM 100 50 0 MILES 50 100

1,000,000 ACRES

1 : 76,032,000

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

DRAFT

Lower Snake River
Juvenile Salmon Migration Feasibility Study

Figure 4.8–1.
TRIBAL RESERVATIONS
1999

GIS Analysts & Graphic Assembly: Applied Technology Team (CENWW-PM-PD-E)
g:\regional\r2k\plates\lsr\jsmeis\crb\crbtr.dgn:GISFILE PLOTTED: 07 DEC 1999

4.8.2.2 Salmon

The decline in salmon has impacted the harvest practices of many, including the tribes. Although it is generally conceded that many factors have contributed to the decline in salmon and Pacific lamprey harvest, the tribes feel that if the dams were removed, they would have a better chance for future increased harvest.

The Tribal Circumstances and Perspectives report includes data and cultural information with regard to the salmon's role in tribal societies. Estimates of salmon populations, rates of decline, and future runs are provided in Technical Appendix A, Anadromous Fish, and Sections 4.5 and 5.4, Aquatic Resources.

In the process of complying with the Endangered Species Act, the Federal agencies have implemented actions specifically designed to benefit salmon. This focus is consistent with treaty and trust responsibilities.

4.8.3 Current Tribal Circumstances

The Tribal Circumstances and Perspectives report states that the study tribes cope with high poverty, unemployment, and death rates. It also provides a tribal perspective with regard to the comparison of present wellbeing of tribes and their non-tribal neighbors. Summary demographic and economic information drawn from this report is presented in Table 4.8-2. While the tribes are generally uncomfortable with statistical treatment of tribal issues, these data allow some degree of comparability and evaluation.

Table 4.8-2. Relative Circumstances of the Five Tribal Circumstances and Perspectives Report Tribes

Socioeconomic Indicator [1]	Nez Perce	Shoshone-Bannock	Yakama Indian Nation	Umatilla	Warm Springs	ID	OR	WA
Families in Poverty (%)	29.4	43.8	42.8	26.9	32.1	9.7	12.4	10.9
Unemployment [2]								
U.S. Census (%)	19.8	26.5	23.4	20.4	19.3	6.1	6.2	5.7
BIA (%)	62.0	80.0	73.0	21.0	45.0			
Per Capita Income ($000s)	8.7	4.6	5.7	7.9	4.3	11.5	13.4	14.9

[1] The data presented in this table are taken directly from the Tribal Circumstances and Perspectives report (Table 41). See the tribe by tribe sections in that report for further information.

[2] Census data (U.S. Bureau of the Census–1990 Census of Population: Social and Economic Characteristics, American Indian and Alaska Native Areas) and BIA data (U.S. Bureau of Indian Affairs, 1995. Indian Service Population and Labor Force Estimates) are both included because census data is more rigorous but tends to overestimate employment. BIA numbers are less rigorous but more likely indicative of tribal circumstances, particularly over winter months.

Source: Meyer Resources, 1999.

4.8.4 Government to Government

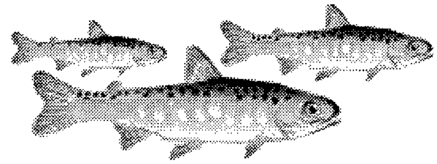
The sovereign status of Indian tribes has long been recognized. Principles outlined in the Constitution, treaties, Federal Statutes, regulations, and executive orders continue to guide national policy towards Indian nations. Working within a government-to-government relationship with Federally recognized Indian tribes, agencies consult, to the extent practicable and permitted by law, with Indian tribal governments; assess the impact of agency activities on resources; ensure that tribal interests are considered before

the activities are undertaken; and remove procedural impediments to working directly with tribal governments on activities that affect the rights of the tribes.

This relationship recognizes that tribal governments are sovereign entities with rights to set their own priorities, develop and manage tribal resources, and be involved through the consultation process in Federal decisions or activities which have the potential to affect these rights. The development of this FR/EIS has included efforts to obtain tribal views of agency responsibilities or actions related to this study, in accordance with provisions of treaties, laws and executive orders, as well as principles lodged in the United States Constitution. Several tribal chairs/leaders have met with Corps commanders/leaders with regard to this study. The Corps has also reached out, through designated points of contact, to involve tribes in collaborative processes designed to facilitate information exchange and consideration of various viewpoints. Tribal members have also participated or attended regional forums or meetings where these issues were discussed.

Numerous documents address Federal responsibilities and policies toward tribes. The Corps' Native American Policy is set forth in the February 1998, Lt. General Joe N. Ballard, *Memorandum for Commanders, Major Subordinate Commands and District Commands: Policy Guidance Letter No. 57, Indian Sovereignty and Government-to-Government Relations with Indian Tribes.* Treaty rights and trust responsibilities are derived and interpreted through statutes, regulations, executive orders, and, court cases, as well as individual treaties.

Technical Appendix N, Cultural Resources, and Technical Appendix Q, Tribal Consultation/Coordination, address the Corps' work toward fulfilling its unique relationship with and obligations to Native American tribes and Indian peoples. The tribal impacts of the alternatives under consideration are being evaluated using many resources including the Tribal Circumstances and Perspectives report and associated sections in Technical Appendix I, Economics; Technical Appendix N, Cultural Resources; Technical Appendix Q, Tribal Consultation/Coordination; and other comments received throughout the study process. The potential effects of the proposed alternatives are discussed in Section 5.7, Native American Indians.



4.9 Transportation

The Columbia and Snake rivers have always been major transportation corridors for humans. As the only near sea-level passage through the Cascades, the Columbia River has consistently provided a key linkage from the ocean to the eastern interior portions of the Pacific Northwest. Oceangoing vessels historically sailed upriver to Vancouver, Washington and Portland, Oregon and then up the Willamette River to Oregon City. When gold was discovered in Idaho in 1862, steamers began traveling from The Dalles, Oregon to Lewiston, Idaho. Navigation between the Columbia and Snake rivers became possible with construction of the Cascades and Dalles-Celilo canals in 1896 and 1915, respectively. Today the Columbia and Snake rivers provide a major water transportation route and the river valleys are used extensively as road and rail transportation corridors.

4.9.1 Navigation

4.9.1.1 Navigation Facilities

The Columbia-Snake Inland Waterway is a 465-mile-long water highway formed by the eight mainstem dams and lock facilities on the lower Columbia and Snake rivers. The waterway provides inland waterborne navigation up and down the river from Lewiston, Idaho to the Pacific Ocean. This system is used for commodity shipments from inland areas of the Northwest and as far away as North Dakota. The navigation system consists of two segments: the downriver portion, which provides a deep-draft shipping channel, and the upriver portion, which is a shallow-draft channel with a series of navigation locks.

The deep-draft portion of the navigation system consists of a 40-foot-deep by 600-foot-wide channel that extends up the Columbia River from the Columbia Bar (River Mile [RM] 3.0) to Vancouver, Washington (RM 105.6). This channel, maintained by the

Corps, is used extensively by oceangoing vessels that transport products and commodities to and from national and international markets. Major import-export terminals are located adjacent to the channel at the Columbia River ports of Vancouver, Longview, and Kalama in Washington, and Portland and Astoria in Oregon.

The shallow draft portion of the waterway is a Federally-maintained channel and system of locks that extends from Vancouver, Washington to Lewiston, Idaho. The channel extends up the Columbia River from Vancouver, Washington (RM 106) to Richland, Washington (RM 345) and from the mouth of the Snake River (Columbia River RM 325) to Lewiston, Idaho (Snake River RM 141). This channel has a minimum authorized depth of 14 feet at the minimum operating pool (MOP) elevations of each of the upriver dams. The authorized channel upriver from Vancouver, Washington to The Dalles, Oregon is 27 feet deep by 300 feet wide but is only maintained to a depth of 17 feet from Vancouver to the Bonneville Dam and to a depth of 14 feet from Bonneville to The Dalles. The authorized channel extending 276 miles from The Dalles to Lewiston is 14 feet deep by 250 feet wide.

The shallow draft portion of the Columbia-Snake Inland Waterway accommodates tugs, numerous types of barges, log rafts, and recreational boats and connects the interior of the basin with deep water ports on the lower Columbia River. Barges and other river traffic need minimum water depths to navigate successfully. River navigation occurs year-round and does not vary by season. Dam operators regulate water releases and maintain reservoir levels to provide minimum navigation depths throughout the year.

Each of the eight mainstem dams maintains a system of locks with sufficient water depth at MOP to allow vessels to pass. These locks provide hydraulic lifts of up to 110 feet in elevation. A summary of the lock characteristics of the eight mainstem dams is provided in Table 4.9-1. In addition to the overall lift, the operating range of a navigation lock is determined by the depth of the sills at the upriver and downriver ends of the lock. The Snake River dams have upriver and downriver sill depths of 15 feet. The Corps does not charge lock fees to commercial and recreational lock users.

Table 4.9-1. Lock Characteristics of the Columbia/Snake River System

River/Lock	River Mile	Year Opened	Age in 2000 (Years)	Chambers (Feet) Width	Length	Lift
Columbia River						
Bonneville (Main)	146	1993	7	86	675	65
Bonneville (Aux.)[1/]	146	1938	62	76	500	65
The Dalles	190	1957	43	86	675	88
John Day	215	1968	32	86	675	110
McNary	292	1953	47	86	675	83
Snake River						
Ice Harbor	9.7	1961	38	86	675	105
Lower Monumental	41.6	1969	31	86	650	103
Little Goose	70.3	1970	30	86	668	101
Lower Granite	107.5	1975	25	86	674	105

1/ Bonneville's first lock, constructed in 1938 to hold two barges and one tugboat at a time, was replaced by a new, larger lock completed in 1993. The new lock can hold five-barge tows, which gives it the same capacity as the seven upriver dams.

Source: DREW Transportation Workgroup, 1999, Table 3-2; Corps, 1999c.

4.9.1.2 Ports

The presence of the Columbia-Snake River Inland Waterway has led to the development of a sizable river-based transportation industry in the region. Riverside facilities managed by port districts and various other public and private entities are located on the pools created by the system of dams and locks. Fifty-four port and other shipping operations provide transportation facilities for agricultural, timber, and other products. There are 27 barge-loading facilities located along the shallow draft portion of the waterway. Thirteen of these facilities are located above Ice Harbor Dam. The remaining 14 facilities located below Ice Harbor Dam include seven located on the Oregon side of the waterway.

4.9.1.3 Shipping Operations

Barge transportation of commodities accounts for virtually all of the commercial shipping activity on the shallow-draft portion of the Columbia-Snake Inland Waterway. Commodities are transported through the waterway system on non-powered barges propelled by tugboats. Typical operations involve a tow, ranging from one to five barges, pushed by a single tugboat.

Transportation firms operating in this portion of the river system in 1995 included Bernert Barge Lines, Brix Maritime Company, James River/Western Transportation Company, Shaver Transportation, and Tidewater Barge Lines, Inc. Data for these and other firms operating in this part of the system are presented in Table 4.9-2. Eight companies accounted for 89 percent of all the shallow-draft vessels operating on this portion of the waterway in 1995. The remaining 11 percent, 22 shallow-draft vessels, were distributed among 13 different companies. Tidewater Barge Lines, Inc., the largest operator, operated 72 vessels and accounted for 51.6 percent of all commodities transported by shallow draft vessel on the Columbia and Snake rivers in 1995.

Table 4.9-2. Barge Transportation on the Shallow Draft Portion of the Columbia-Snake Inland Waterway in 1995

Company	Total Vessels Operated	% of Total Vessels	Tons (000s)	% of Total Tons	Trips	% of Total Trips
Tidewater Barge Lines, Inc.	72	36.4	5,588.5	51.6	2,674	34.1
James River/Western Transportation	36	18.2	1,268.7	11.7	2,305	29.4
Shaver Transportation Co.	14	7.1	1,150.5	10.6	368	4.7
Brix Maritime Co.	24	12.1	886.2	8.2	1,290	16.5
Bernert Barge Lines	14	7.1	519.2	4.8	364	4.6
SDS Lumber Co.	5	2.5	310.4	2.9	125	1.6
Ross Island Sand and Gravel Co.	6	3.0	54.5	0.5	121	1.5
Sause Brothers Ocean Towing Co.	5	2.5	41.1	0.4	11	0.1
Other Companies (13)	22	11.1	1,001.2	9.3	577	7.4
Total	**198**	**100**	**10,820.3**	**100**	**7,835**	**100**

Source: DREW Transportation Workgroup, 1999, Table 3-4

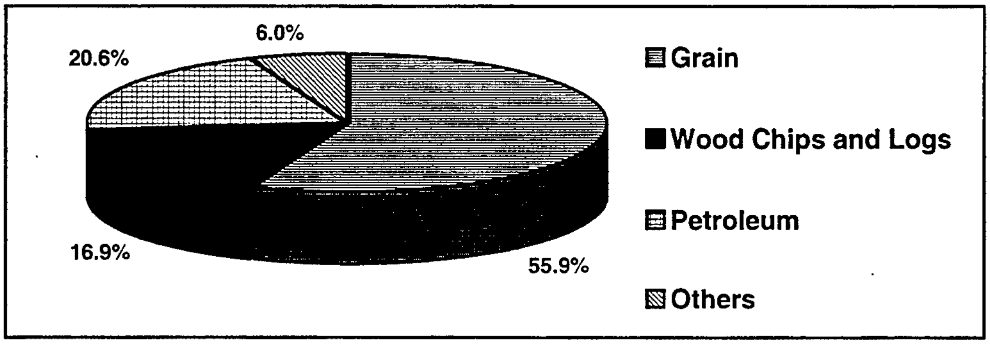
In addition to barge transportation, commercial shipping operations include some passenger service. Three cruise lines operate four tour boats between Portland and Clarkston in spring and fall. Week-long tours regularly depart Portland, travel upriver to Clarkston, and then return to Portland. These tours are generally scheduled from the

beginning of April through the first week of June, and again from September through the first half of November.

4.9.1.4 Commodity Movements

Columbia-Snake Inland Waterway

Over 45 different commodities were transported on the shallow-draft portion of the Columbia-Snake Inland Waterway in 1995. Three commodity groups—grain, petroleum products, and wood chips and logs—accounted for over 90 percent of the total tonnage transported. The relative contribution of these four commodity groups is highlighted in Figure 4.9-1. Grain alone accounted for approximately 56 percent of the total tonnage transported in 1995.

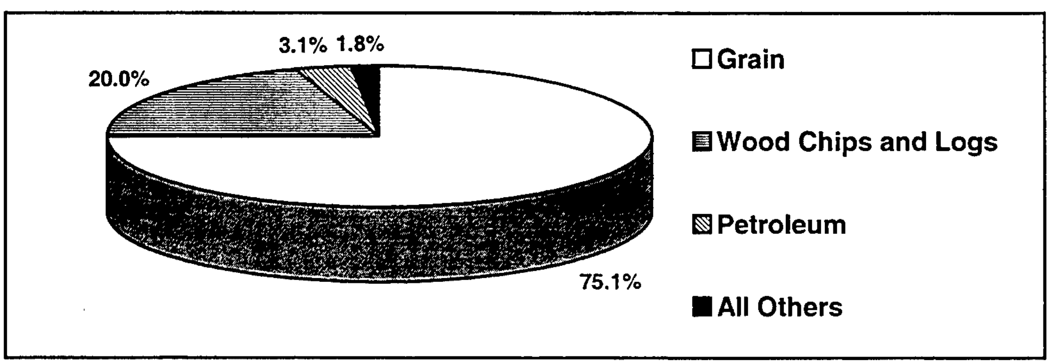


1/ Source: DREW Transportation Workgroup, 1999, Table 4-6

Figure 4.9-1. Tonnage Transported on the Shallow Draft Portion of the Columbia-Snake Inland Waterway in 1995 by Commodity Group

Lower Snake River

Commodity movement on the lower Snake River is dominated by grain, with wheat and barley making up approximately 75.1 percent of the tonnage passing through Ice Harbor lock in 1995 (Figure 4.9-2). Wood products, including wood chips and logs, accounted for 20 percent and petroleum products accounted for another 3.1 percent, with the remaining 1.8 percent composed of a variety of products including other farm products, chemicals, and sand and gravel. Table 4.9-3 provides a summary of the annual tonnage by commodity passing through Ice Harbor lock for 1987 through 1996.



Source: DREW Transportation Workgroup, 1999

Figure 4.9-2. Tonnage Transported on the Lower Snake River above Ice Harbor Dam in 1995 by Commodity Group

The Columbia-Snake Inland Waterway from Lower Granite pool through McNary Dam handled cumulative totals of approximately 6.7 million tons in 1990, 7 million tons in 1991, and 6.7 million tons in 1992. This included upbound and downbound cargo originating at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and McNary reservoirs (Corps and NMFS, 1994). Since 1980, cumulative cargo volumes have ranged from approximately 5 to 8 million tons per year. Tonnage using at least a portion of the Snake River segment, as measured by the figures for Ice Harbor, averaged about 3.8 million tons per year from 1980 through 1990. This average increased slightly to about 4 million tons per year from 1991 through 1996 (Table 4.9-3). The following discussion addresses shipments of grain, wood products, and petroleum products in turn.

Table 4.9-3. Tonnage by Commodity Group Passing Through Ice Harbor Lock 1987-1996 (in thousand tons)

Commodity[1/]	1987	1988[2/]	1989[2/]	1990	1991	1992	1993	1994	1995	1996[3/]	10 Year Average
Grain	2,906	3,981	2,532	3,109	3,241	2,612	2,706	3,135	3,471	2,821	3,051
Wood Chips and Logs[4/]	507	446	365	346	449	561	899	968	925	558	602
Petroleum	117	105	115	108	106	108	129	137	144	95	116
All Others	96	127	203	166	159	80	57	74	82	85	113
Total	**3,626**	**4,659**	**3,215**	**3,729**	**3,955**	**3,361**	**3,791**	**4,314**	**4,622**	**3,559**	**3,883**

1/ All figures are rounded to the nearest 1,000.
2/ Large movements of 1.2 million tons in 1988 and 1.4 million tons in 1989 have been omitted because they appear to have been one time movements and would significantly skew the "All Other" category that they were classified in (DREW Transportation Workgroup, 1999.
3/ Ice Harbor lock was out-of-service from January 1 through March 9 while the downriver lift gate was being replaced.
4/ The data presented here for the Wood Chips and Logs commodity group also includes the Corps' Wood Products commodity group. Wood Chips and Logs comprised 92 percent of the combined total in 1995.
Source: DREW Transportation Workgroup, 1999, Table 4-7

Grain

In general, downriver tonnage is typically more than nine times the volume of upriver tonnage. This volume difference is primarily because of the large movements of grain bound for lower Columbia River export terminals. Typical downriver barge operations involve one barge of general cargo or wood chips moved in a tow with two or more grain barges. Without the large grain movements, it is likely that either rates for transporting other cargoes would be substantially higher or barge service would be unavailable. Origin/destination data for wheat and barley indicate that virtually all barge traffic originating above Ice Harbor lock moves from one of the Snake River ports of Lewiston (Clearwater River), Clarkston, Wilma, Almota, Central Ferry, Lyons Ferry, Windust, or Sheffler to the ports of Portland, Vancouver, or Kalama on the lower Columbia River. Wheat and barley cargoes are subsequently transferred to deep draft vessels for export. Between 1987 and 1996, barge shipments of wheat and barley originating above Ice Harbor lock ranged from 2,532,000 tons in 1989 to 3,981,000 tons in 1988, with an annual average of 3,051,000 tons.

Approximately 22 percent of grain transported on the lower Snake River originates in Idaho. Approximately 86 percent of this total is loaded onto barges at Lower Granite with the remaining 14 percent loaded at Little Goose. Grain grown in Washington accounts for approximately 69 percent of total lower Snake River grain shipments, with 53 percent of this total loaded onto barges at Little Goose. Approximately 26 percent of

Washington grain shipments are loaded on barge at Ice Harbor, with the remaining 21 percent divided between Lower Granite (15 percent) and Lower Monumental (6 percent). Shipments from Montana and North Dakota account for approximately six and three percent of total grain shipments transported on the lower Snake River, respectively, with less than one percent of shipments originating in Utah. Wallowa County, Oregon provides the remaining one percent of annual lower Snake River grain shipments (Table 4.9-4).

Table 4.9-4. Grain Shipments on the lower Snake River by State of Origin and Reservoir (in bushels)

Reservoir	Lower Granite Bushels (000s)	Lower Granite % of Total	Little Goose Bushels (000s)	Little Goose % of Total	Lower Monumental Bushels (000s)	Lower Monumental % of Total	Ice Harbor Bushels (000s)	Ice Harbor % of Total	Total Bushels (000s)	Total % of Total
Idaho	23,480	49	3,910	8	0	0	0	0	**27,390**	**22.2**
Oregon	1,180	2	0	0	0	0	0	0	**1,180**	**1.0**
Washington	12,880	27	44,570	92	5,210	100	22,050	100	**84,710**	**68.6**
Montana	6,780	14	0	0	0	0	0	0	**6,780**	**5.5**
North Dakota	3,270	7	0	0	0	0	0	0	**3,270**	**2.6**
Utah	140	0	0	0	0	0	0	0	**140**	**0.1**
Bushels by Reservoir	**47,730**	**100**	**48,480**	**100**	**5,210**	**100**	**22,050**	**100**	**123,470**	**100.0**
% by Reservoir		**38.7**		**39.3**		**4.2**		**17.9**		

Source: DREW Transportation Workgroup, 1999, Tables 5-2 through 5-5
Note: These data are based on a survey of grain elevators on the lower Snake River. This survey was designed to establish grain origin and movement patterns for a "representative year" of operations. In some cases the data were obtained for May 1997 through April 1998. In other cases facility operators provided adjustments to data compiled for the Columbia River System Operation Review EIS but no actual new data. As a result, these data are representative of current conditions but cannot be directly associated with a particular year.

Wood Products

Annual shipments of wood products, chips, and logs, the second largest commodity group using the Snake River above Ice Harbor lock, ranged over the 1987 to 1996 period from 346,000 tons in 1990 to 968,000 tons in 1994, with an annual average of 602,000 tons. The Corps classifies commodities on each barge traveling up and down the Columbia-Snake Inland Waterway by commodity group. Lumber, logs, wood chips, pulp, and paper products are included in the wood products commodity group summarized here. Logs and wood chips comprised approximately 92 percent of wood products shipped on the lower Snake River in 1995 (DREW Transportation Workgroup, 1999).

Based on data compiled in the Corps annual and monthly Lock Tonnage Reports for 1980 through 1995, the majority of wood products travel downriver and movements tend to occur throughout the year. Wood products typically enter the Columbia-Snake Inland Waterway at the Lower Granite pool and travel downriver through the Snake River dams, with no tonnage added or removed until McNary pool. Additional wood products are often added at McNary pool. These patterns suggest that wood products transported on the lower Snake River are typically harvested in the eastern regions of the Pacific Northwest, delivered by truck or rail to the Lower Granite or McNary pools, and then

barged downriver for processing, shipment to other states, or international export (Lee and Casavant, 1996). Upbound movements of wood products tend to be concentrated in the Columbia River portion of the waterway and are typically offloaded at McNary pool, with a relatively small portion of total tonnage continuing up the Snake River to the Lower Granite pool (Lee and Casavant, 1996).

Petroleum Products

The majority of petroleum product shipments, the third largest commodity group transported on the lower Snake River, originate in the Portland area and move upriver to a terminal at Wilma on the Lower Granite Reservoir. Petroleum products, the third largest commodity group transported on the lower Snake River, generally account for approximately 80 percent of all upriver commodity movements above Ice Harbor lock (Corps and NMFS, 1994). Annual petroleum product shipments ranged from 95,000 tons in 1996 to 144,000 tons in 1995, with an annual average of 116,000 for the period 1987 through 1996 (Table 4.9-4). Upbound movements of petroleum products generally occur throughout the year but movements of gasoline, jet fuel, and kerosene tend to be higher from March through September, with increased demand coinciding with spring planting and fall harvesting seasons. Upriver shipments of distillate, residual, and other fuel oils are also steady throughout the year, but tend to peak in September during harvest. The majority of upriver petroleum product shipments on the Columbia-Snake Inland Waterway tend to be unloaded at McNary pool, for distribution by truck and rail. The remaining portion is typically left on barges and transported up the Snake River to Lower Granite pool (Lee and Casavant, 1996).

4.9.1.5 Upper River Navigation

The 465-mile-long Columbia-Snake Inland Waterway ends at the head of the Lower Granite Reservoir. River reaches upriver of the Lower Granite Reservoir are used for various types of navigation, with recreation uses the most common. Many types of motorized and non-motorized pleasure craft are used by private boaters on the Snake and Clearwater rivers above the Lower Granite Reservoir. Commercial tour, guiding, and transportation services also exist in some locations, particularly on the Hells Canyon reach of the Snake River upriver from Lewiston.

4.9.2 Railroads

Railroads provide another mode of commodity transport within the Columbia Basin. Grain moved to export elevators via rail is normally delivered by truck to county elevators where it is loaded on rail cars. Rail transportation consistently accounted for over half of the total annual receipts of wheat and barley at Columbia River export houses from 1981 through 1997. Direct truck transportation averaged approximately 2 percent of the total over the same period. The remaining shipments of wheat and barley were transported by barge. Summary data for the 1990-1991 through 1996-1997 crop years are presented in Table 4.9-5.

Wheat and barley represent a significant portion of total rail grain traffic moving through the region, but more than half of this grain traffic involves corn, most of which originates from Nebraska, Minnesota, or South Dakota. Rail grain traffic has remained relatively constant at the Port of Portland over the past decade. Traffic has increased at the Port of Vancouver, while the Port of Longview no longer exports grain. In the Puget Sound

Table 4.9-5. Receipts of Wheat and Barley at Columbia River Export Houses by Mode of Transportation (in thousands of bushels)

	Rail		Barge		Truck		Total
Year	**Bushels**	**Percent**	**Bushels**	**Percent**	**Bushels**	**Percent**	**Bushels**
1990-91	254,514	57.3	179,528	40.4	10,505	2.4	**444,547**
1991-92	251,942	59.6	162,067	38.4	8,406	2.0	**422,415**
1992-93	267,143	61.6	155,888	36.0	10,456	2.4	**433,487**
1993-94	317,299	61.9	185,589	36.2	9,353	1.8	**512,241**
1994-95	315,989	63.0	176,540	35.2	9,282	1.8	**501,811**
1995-96	343,136	59.4	227,163	39.3	7,564	1.3	**577,863**
1996-97	258,778	55.0	203,353	43.2	8,055	1.7	**470,186**

Source: Casavant and Lee, 1998

region, rail grain traffic has declined at the Port of Seattle and fluctuated significantly at the Port of Tacoma.

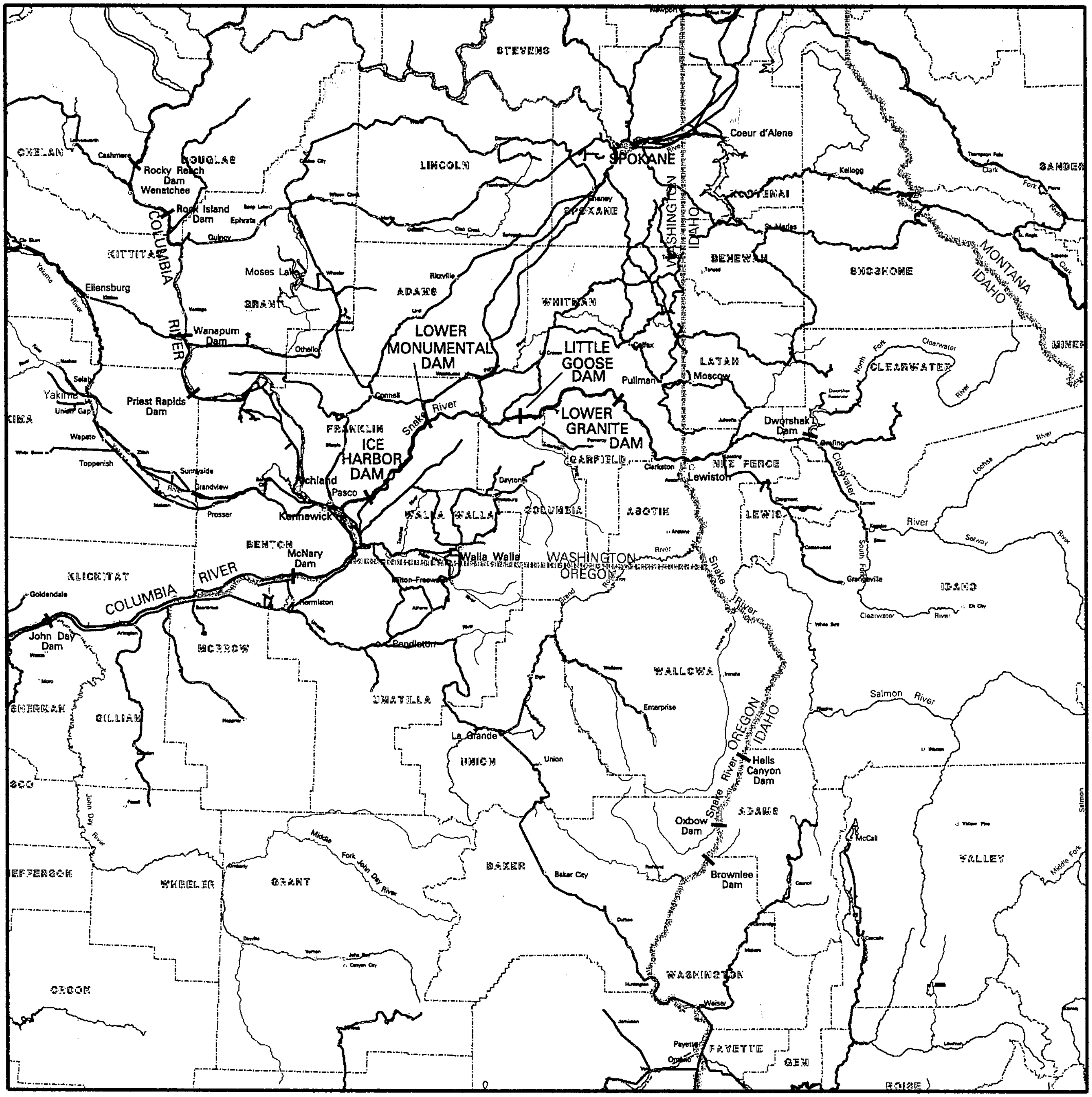
The most dramatic regional change in rail grain traffic has been the increasing volume of long-haul midwestern corn moved to the Columbia River Port of Kalama. Most of the major Columbia River ports with deep-water access unload grain arriving by barge and rail car and transfer it to deep-water vessels for shipment to export markets. The existing storage and rail car and barge unloading capacities at these facilities are identified in Table 4.9-6.

Table 4.9-6. Existing Rail and Barge Grain Unloading Capacities at Columbia River Deep Water Ports

Company	**Port Location**	**Operating Storage Capacity (Bushels)**	**Receiving Facilities**	**Rail Car Unload Capacity (Tons)**	**Barge Unload Capacity (Tons)**
United Harvest	Vancouver, WA	4,230,000	barge, rail	14,000	10,000
Louis Dreyfus	Portland, OR	1,500,000	barge, rail	3,000	7,000
Cargill (Irving Elevator)	Portland, OR	1,500,000	barge, rail, truck	5,500	10,000
Cargill	Portland, OR	7,500,000	barge, rail, truck	5,500	7,000
Columbia Grain	Portland, OR	4,000,000	barge, rail, truck	10,000	10,000
United Harvest	Kalama, WA	6,000,000	barge, rail, truck	7,000	7,000
Kalama Export	Kalama, WA	2,000,000	barge, rail	40,000	12,000
Total		**26,730,000**		**85,000**	**63,000**

Source: DREW Transportation Workgroup, 1999, Table 3-1

Based on origin-destination relationships for commodities shipped on the Columbia-Snake Inland Waterway, the areas potentially affected by the proposed action are primarily the grain growing areas of Washington, Oregon, Idaho, Montana, and North Dakota. These areas are served by the Burlington Northern-Santa Fe Railroad (BNSF), the Union Pacific Railroad (Union Pacific), and several shortline operations including the Camas Prairie Railroad, which serves Idaho and Washington, and the Montana Rail Link, which serves Idaho and Montana. Regional railroads are shown in Figure 4.9-3.



Special Note: Railroads may not all be operational or currently in use.

RAILROADS

BOUNDARIES

State

County

KM
40 20 0

MILES
20 40

160,000
ACRES

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

1 : 2,534,400

DRAFT

Lower Snake River
Juvenile Salmon Migration Feasibility Study

Figure 4.9-3.
REGIONAL RAILROADS

GIS Analysts & Graphic Assembly: Applied Technology Team (CENWW-PM-PD-E)
g:\regional\reg\plates\lsr\jsmeis\lsrg\lsrgrr.dgn:GISFILE PLOTTED: 07 DEC 1999

1999

In Washington, BNSF and Union Pacific have an agreement to jointly manage the mainline track from Seattle to Portland. From Vancouver, Washington, the BNSF line runs along the northern side of the Columbia River through the Tri-Cities to Spokane. It continues north to Sandpoint, Idaho, then runs southeast to Missoula, Montana and on into the Midwest. BNSF has crossings into Oregon at Portland, Wishram, and Wallula. The Union Pacific line runs along the southern side of the Columbia River from Portland to Hinkle, Oregon, then runs south to Boise and on into the Midwest. Both BNSF and Union Pacific provide extensive trackage in all four states.

The Camas Prairie Railroad is a joint venture operated cooperatively by BNSF and Union Pacific. Camas Prairie tracks originating at Revling and Kamiah in Idaho, pass through Lewiston, Idaho to connect with Riparia, Washington on the Lower Monumental Reservoir. Montana Rail Link provides service from Sandpoint, Idaho to Garrison, Montana (Corps and NMFS, 1994).

4.9.3 Highways

Trucks are also used for commodity transport, particularly for the movement of petroleum and chemical products to inland destinations. Trucks are also used in conjunction with other modes of transportation. This section provides a discussion of current truck transportation patterns for eastern Washington grain shipments and an overview of potentially affected local and regional highways.

4.9.3.1 Eastern Washington Grain Shipments

Wheat and barley compose approximately 75 percent of the total tonnage transported on the lower Snake River. A significant portion of this wheat and barley is harvested in eastern Washington and transported by truck to lower Snake River ports, especially the ports of Windust and Almota on Little Goose Reservoir. At these ports, wheat and barley shipments are transferred to barge and transported downriver. These existing patterns are discussed here to provide more detailed insight into potentially affected traffic patterns and highway maintenance costs. Highway access to the nine lower Snake River ports is limited. Therefore, other commodities transported by truck to lower Snake River ports likely converge on the same primary routes as wheat and barley shipments.

Eastern Washington wheat and barley, harvested in July and August, is usually transported by truck to elevators or river ports, which serve as short- and long-term facilities, transfer stations, and points of consolidation. Grain stored in elevators is subsequently trucked to river ports for barge shipment to Portland (61 percent), shipped via rail directly to Portland (23 percent), or trucked to another elevator for rail transport to Portland (13 percent) (Newkirk et al., 1995). Upbound products arriving at river terminals are typically transported to their final destinations by truck.

Detailed information concerning eastern Washington grain elevator location, capacity, handling and storage rates, and transportation modal usage was obtained through a survey of grain elevators conducted in 1994 (Newkirk et al., 1995). Grain shipments from townships, or production areas, to river ports comprise 57 percent of grain-related truck miles, with township to elevator and township to elevator with rail comprising approximately 14 percent each (Jessup and Casavant, 1998). The ports of Windust and Almota account for 38 and 15 percent of wheat shipped by truck to river ports, respectively.

Approximately 28 percent of eastern Washington wheat transported by truck is moved to river ports at or below the Tri-Cities. Primary truck routes to these ports are State Routes (SRs) 21 and 263 (Port of Windust), SR 192 and 195 (Port of Almota), SR 127 (Port of Central Ferry), and SR 395 (ports at or below the Tri-Cities) (Jessup and Casavant, 1998). Truck shipments of barley follow a similar pattern with shipments converging on the primary corridors serving Snake River ports. However, a larger percentage of barley is transported by truck to the Tri-Cities, using Interstate 82 as well as SR 395. Tonmiles of eastern Washington grain shipments and associated existing annual infrastructure investments are presented in Table 4.9-7 by highway type.

Table 4.9-7. Eastern Washington Grain Shipments: Tonmiles and Highway Infrastructure Needs

Highway Type	Tonmiles	Percent of Tonmiles	Infrastructure Investment ($)	Percent
Interstate	29,053,431	6.7	58,089	0.8
State	309,597,521	71.1	3,096,555	44.0
County	96,983,339	22.3	3,879,296	55.2
Total	**435,634,291**		**7,033,940**	

Source: Jessup and Casavant, 1998 (Tables 7 and 34)

Data compiled by the DREW Transportation Workgroup (1999) suggest that grain shipments originating in Idaho tend to be transported by truck to Lewiston via SR 95.

4.9.3.2 Local and Regional Highways

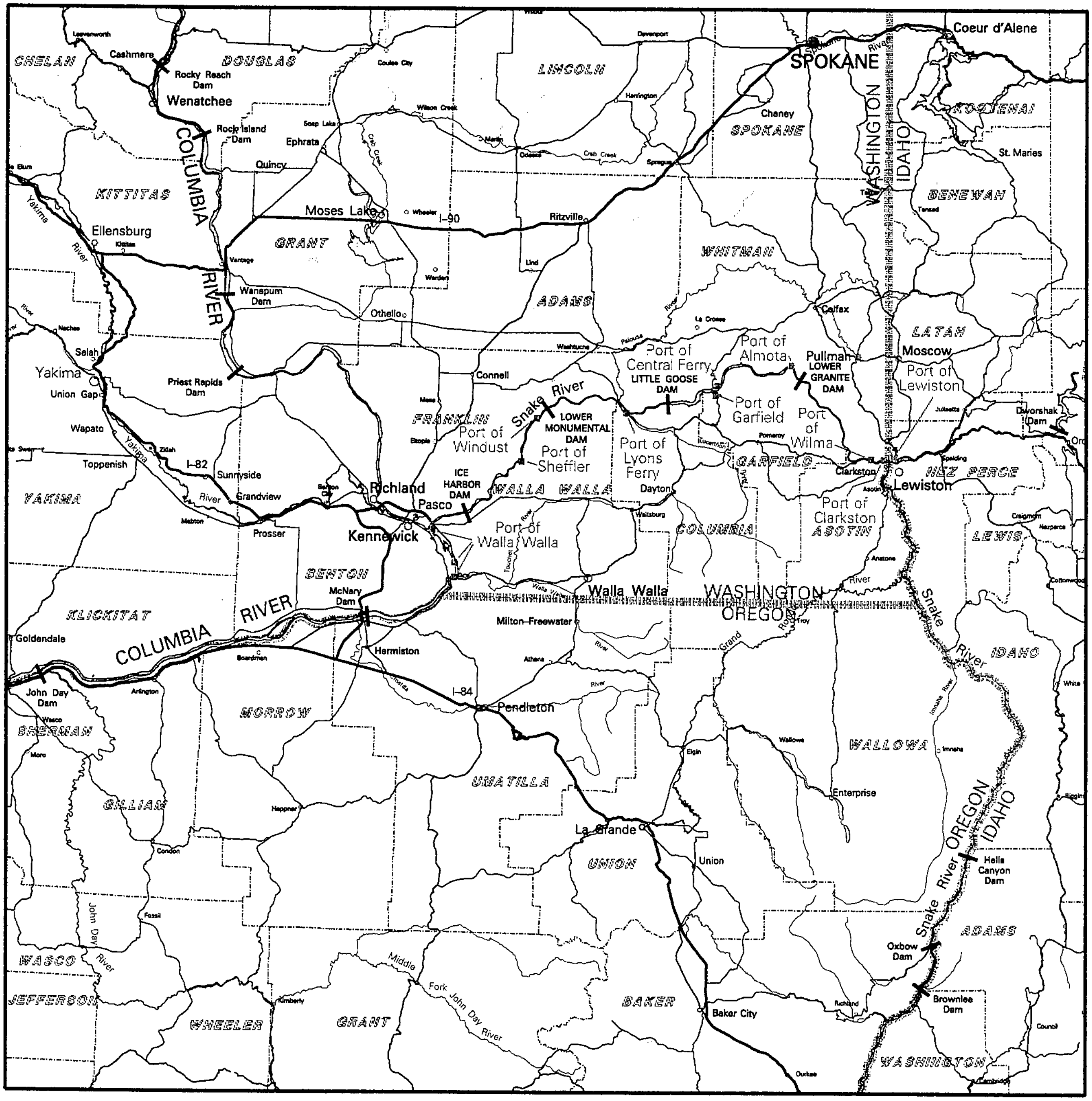
The highway network serving the study area includes Federal, state, and county highways (Figure 4.9-4). Routes that could be affected by potential diversion of commodities from barge transportation are identified in Table 4.9-8 as primary and secondary facilities. Alternative routes north of the lower Snake River pools are also identified. The majority of the links in the network tend to serve low traffic volumes (Corps and NMFS, 1994). Interstate 84 and some portions of SR 395 have four travel lanes. The majority of the remaining primary and secondary highways have two travel lanes. These highways generally serve rural areas with few large population concentrations.

The four lower Snake River dams serve as bridges across the river. Lower Granite Dam connects Lower Deadman Road on the south side of the river with Almota Road on the north. Lower Monumental Dam connects Lower Monumental Road on the south side of the river with Devils Canyon Road on the north. Ice Harbor and Little Goose dams both have road crossings that appear to be used primarily by project operators and tourists. Although the local population uses the four dams to cross the river, they are not part of the highway system.

Table 4.9-8. Potentially Affected Highways

Highway	Segment/Location From	To
Primary Highways		
I-84	US 97 (Biggs)	Pendleton
I-82	I-84	US 395 (Pasco)
US 395/730	I-84	US 12
US 12	US 395 (Pasco)	Lewis County, ID
US 95	Lewis and Adams Counties, ID	
OR 11	I-84	WA state line
WA 14	US 97 (Maryhill)	I-82 (Plymouth)
WA 124	US 12 (near Pasco)	US 12 (Waitsburg)
WA 125	WA 125	OR state line
WA 193	US 12	Port of Wilma
Secondary Highways		
US 395	US 12 (Pasco)	WA 260 (near Mesa)
WA 260	US 395	WA 261
WA 261	WA 260	US 12
WA 127	US 12	Central Ferry
WA 129	US 12	OR state line
WA 397 (proposed)	US 395	Finley Industrial Park
Alternative Routes North from Snake River		
US 195	US 12	WA 26
WA 26	US 195	US 395
WA 260	WA 261	WA 26
WA 263 (proposed)	WA 260 (Kahlotus)	Windust

Source: Corps and NMFS, 1994



HIGHWAYS

Interstate

U.S.

State

PORTS

KM 300 100 0 MILES 7.5 15 30

125,000 ACRES

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

1 : 1,900,800

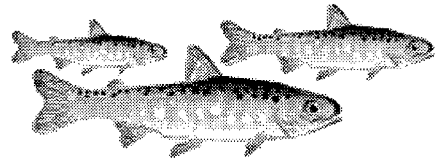
DRAFT

Lower Snake River
Juvenile Salmon Migration Feasibility Study

Figure 4.9–4.
ROADS, HIGHWAYS, AND PORTS

GIS Analysis & Graphic Assembly: Applied Technology Team (CENWW-PM-PD-E)
g:\regional\reg\plates\lsr\jsmeis\lsrg\lsrghwy.dgn:GISFILE PLOTTED: 07 DEC 1999

1999



4.10 Electric Power

4.10.1 Generation

The Columbia River and its tributaries are extensively developed for hydroelectric power, with over 250 Federal and non-Federal dams constructed since the 1930s. These include 30 major multiple use facilities built by Federal agencies on the Columbia River and its tributaries. These facilities fall into two major categories: storage and run-of-river projects. The main purpose of storage reservoirs is to store water for use at a later time. The downstream effect of a storage facility is to adjust the river's natural flow patterns to conform more closely to water uses. These projects store spring runoff water which is gradually released for many river uses, including power, in late summer, fall, and winter when stream flows would ordinarily be low.

The hydraulic capacity at each storage facility is typically at least two times the average annual streamflow, allowing generating operations to provide additional power during high-flow periods. Run-of-river facilities, like the four lower Snake River dams, are developed primarily for navigation and hydropower generation. These dams have limited storage capacity and pass water at nearly the same rate that it enters the reservoir. Reservoir levels behind these dams vary only a few feet during normal operations.

Power generating operations follow a variety of cyclic patterns. Hydroelectric projects can increase or decrease their generation rapidly and are, therefore, usually operated to follow the peaks in power demand. Output levels typically vary significantly on a daily basis, with generation much higher during daylight hours than at night. On a weekly basis, power loads and generation tend to be considerably higher on weekdays than on weekends. The eight mainstem dams — the four lower Snake River dams and the McNary, John Day, The Dalles, and Bonneville dams on the lower Columbia River —

tend to follow these daily and weekly cycles, causing reservoir levels to fluctuate frequently within the normal operating range.

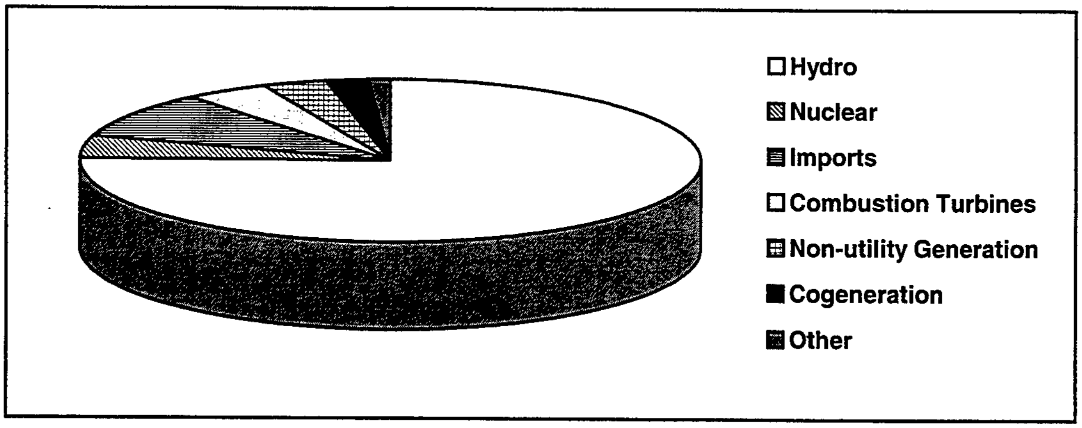
The four lower Snake River dams are currently operated in accordance with the 1995 Biological Opinion. The Corps operates Little Goose, Lower Monumental, and Ice Harbor dams within one foot of minimum operating pool (MOP) from approximately April 10 through August 31. Lower Granite Dam is operated within one foot of minimum operating pool from approximately April 10 through November 15. MOP elevations for Lower Granite, Little Goose, Lower Monumental, and Ice Harbor dams are 733 feet, 633 feet, 537 feet, and 437 feet mean sea level (msl), respectively. During the rest of the year, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor dams operate at elevations of 138 feet, 638 feet, 540 feet, and 440 feet msl, respectively. This operation restricts the daily and weekly operation of these dams to meet peak power demands.

Power demand is higher in the winter and lower during the spring and summer in most of the Pacific Northwest. During the winter, both the storage and run-of-river projects are operated to provide peaking output during the high demand periods of the day. However, since river inflows are much lower during the winter than in the spring and early summer, operation is often limited to peak hours during the winter. The hydropower plants in the Pacific Northwest generate most of their energy in the spring and early summer during high runoff periods. Annual streamflow patterns also influence generation patterns. During years of relatively high runoff, hydroelectric plants are often operated at high levels in the spring to take advantage of the surplus water to generate additional energy. Power planners try to maximize hydroelectric production during the spring runoff period to avoid spilling water that can be used for power generation. This may involve deliberately keeping thermal plants inactive. As a result, hydropower generation may be significantly higher during the spring months than during the rest of the year. Maximum levels of generation occur at the four lower Snake River dams during the spring runoff period.

4.10.2 Regional Power Supply and Sales

The Bonneville Power Administration (BPA) is the Federal agency responsible for selling the electricity generated at the Corps and BOR hydropower projects in the Pacific Northwest. From the revenues collected from the sale of electricity, BPA repays the Federal Treasury the costs associated with building and operating the Federal hydropower projects. If the four lower Snake River dams are breached, they will not produce any hydropower and BPA's revenue will be reduced. This section provides a brief summary of the sources of electricity generation in the Pacific Northwest and the nature of the power market.

The integrated system of 30 Federal hydroelectric facilities in the Columbia River Basin has a total installed nameplate generating capacity of about 19,600 megawatts (MW) (BPA, 1993). Hydropower (Federal and non-Federal), on average, accounts for approximately 60 percent of total regional energy needs and 70 percent of total electrical generating capacity. The remainder of the region's electricity comes from non-Federal hydroelectric facilities and from thermal resources, including coal-fired, nuclear, and gas-fired plants (Figure 4.10-1).



Source: BPA, 1997

Figure 4.10-1. Pacific Northwest Electric Generation by Resource Type

Summary information on Pacific Northwest electric generating facilities is presented in Table 4.10-1. Information is provided on sustained yield capacity, measured in MW, and firm energy, measured in annual average MW (aMW)—the average of the MW produced over the entire year at 8,760 hours. For hydroelectric facilities, firm energy is the amount of energy that can be generated assuming a repeat of one most extreme low water year. The low water year of 1936-1937 is the baseline used to calculate the firm energy produced by the region's hydroelectric facilities (Table 4-10.1). This year has been defined as the critical year for defining firm energy in many regional power planning studies.

Table 4.10-1. Pacific Northwest Electric Generating Resources

Resource Type	Sustained Peak Capacity (MW)	Firm Energy (aMW)
Hydro	25,887 (67%)	12,187 (57%)
Coal	4,521 (12%)	4,061 (19%)
Nuclear	1,162 (4%)	841 (4%)
Imports	2,296 (8%)	1,669 (8%)
Combustion Turbines	1,665 (4%)	753 (3%)
Non-utility Generation	1,166 (3%)	1,051 (3%)
Cogeneration	775 (2%)	675 (3%)
Other	264 (1%)	171 (1%)
Total	**38,436**	**21,408**

Source: BPA, 1997

4.10.2.1 Firm Sales

Publicly-owned utilities in the Pacific Northwest have first call or "preference" on power produced at Federal hydroelectric facilities. BPA has long-term firm power sales contracts with over 120 utilities, including municipalities, public utility districts, and rural cooperatives. BPA also sells firm power directly to other Federal agencies and some of the region's largest industries. These industries are known as direct service industries (DSIs). BPA supplied 15 DSI customers in 1995, 8 of which were aluminum companies (BPA, 1995). BPA's firm

power sales contracts are long-term commitments that contain a guarantee to meet some or all of a customer's load requirements over a defined period. These contracts are based on estimates of the firm energy load-carrying capability (FELCC) of the system.

4.10.2.2 Nonfirm Sales

Nonfirm energy is power generated above the amount needed to meet firm power commitments. In most water years, stream flows are high enough to produce at least some nonfirm generation. In an average year, nonfirm generation may comprise 25 percent or more of total hydro system output. Nonfirm energy is generally sold with no guarantee of continuous availability and delivery can be terminated at very short notice. DSIs have first call on BPA's nonfirm energy. The remainder is sold to utilities in the Pacific Northwest and elsewhere.

4.10.2.3 Regional Exports

In wet years, the amount of hydropower generation can be significantly greater than under average or low-flow conditions and this energy can serve as a major portion of the energy exported from the Pacific Northwest region. In low water years, or during high demand periods within a year, energy is often imported into the region from other western states and Canada. The Pacific Northwest region is part of an interconnected power system that includes all or part of 14 western states, two Canadian provinces, and a small area of northern Mexico. This area, managed by the Western Systems Coordinating Council (WSCC), extends over 1.8 million square miles and includes four major areas—the Northwest Power Pool Area, the Rocky Mountain Power Area, the Arizona-New Mexico Power Area, and the California-Southern Nevada Power Area—with varied geographic and climatic conditions. Changes in Pacific Northwest hydropower generation could affect the amount of energy bought and sold, and the amount of new generating facilities built, throughout this area.

In the past several years, the entire electrical industry has been undergoing drastic changes from a regulated industry of the past into a partially competitive industry. One of the most significant changes was a final rule issued by the Federal Energy Regulatory Commission (FERC) in 1996 which required utilities that own, control, or operate transmission lines to file non-discriminatory open access tariffs that offer others the same electricity transmission service that they provide themselves. Open transmission access improved the flexibility to purchase electricity from generation facilities in the Pacific Northwest, the Pacific Southwest, and other WSCC areas. In early 1998, the State of California implemented significant legislation to set up a formal market system in which a wide range of wholesale buyers and sellers can contract for electricity sales. The hydropower generated in the Pacific Northwest has become an integral part of the California power exchange and is an important regional export.

Transmission lines originate at generators at the dams and extend outward to form key links in the regional transmission grid. BPA owns and operates the transmission system, which consists of 14,787 circuit miles (BPA, 1995). The Pacific Northwest grid was designed to accommodate, and interact electrically with, existing generation sources, including the four lower Snake River hydroelectric facilities. The grid relies upon these and other fixed sources of generation to serve regional loads and move bulk power.

Nonfirm sales between the Pacific Northwest and other regions are mutually advantageous. In California, for example, Pacific Northwest nonfirm energy sales allow

California utilities to shut down their relatively high cost oil- and gas-fired generating plants, reducing operating costs and pollution. Nonfirm export sales, in turn, bring in revenues to the Pacific Northwest and help keep electricity rates in the region among the lowest in the United States.

4.10.3 Lower Snake River Facilities

4.10.3.1 Project Characteristics and Combined Capacity

The four lower Snake River dams are run-of-river facilities. Power generating facilities at the four dams are summarized in Table 4.10-2 by facility, installed capacity ranges from 603 MW at Ice Harbor to 810 MW at Lower Granite, Little Goose, and Lower Monumental. The overload capacity, the maximum output that can be achieved, is 693 MW for Ice Harbor and 931 MW for each of the other three lower Snake River facilities.

Table 4.10-2. Hydroelectric Power Plant Characteristics

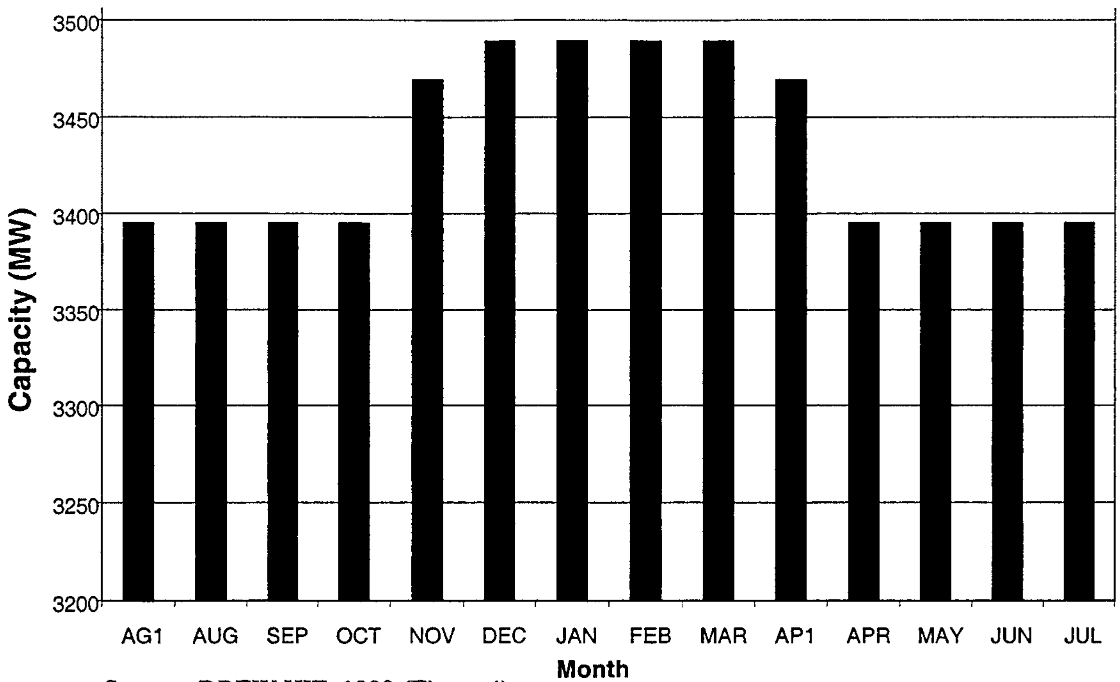
	Lower Granite	Little Goose	Lower Monumental	Ice Harbor	Lower Snake Total
Number of Units	6	6	6	6	**24**
Capacity Per Unit (MW)	135	135	135	3 (90) 3 (111)	
Total Nameplate Capacity (MW)	810	810	810	603	**3,033**
Overload Capacity (MW)	931	931	931	693	**3,486**
In-Service Date	1975 1978	1970 1978	1969 1970 1979	1961 1962 1975	
Average Annual Energy (aWh)	333	317	332	264	**1,246**
Plant Factor (%)	36	34	36	38	**36**

Source: DREW HIT, 1999 (Table 1)

The total nameplate peaking capacity of the four lower Snake River facilities is 3,033 MW (Table 4.10-2), which is approximately 15 percent of the peaking capacity at the Federal power system in the Pacific Northwest region and 7 percent of the total peaking capacity of all power facilities in the Pacific Northwest region. The four lower Snake River dams provide about 11 percent of the energy generated in the Federal power system in the Pacific Northwest region, and 5 percent of all energy generated in the Pacific Northwest region.

The monthly capacity of the lower Snake River dams is shown in Figure 4.10-2. The monthly amounts shown in this figure represent the maximum monthly generation of these projects under current operation. The projects do not always operate at these maximum outputs because there is insufficient water to do so for long periods of time. All four dams are run-of-river facilities with limited reservoir storage.

The lower capacity from April through October reflects the operation criteria established in the 1995 Biological Opinion. The lower Snake River facilities are operated at their MOP during this period to increase migrating salmon and steelhead survival rates.



Source: DREW HIT, 1999 (Figure 4)

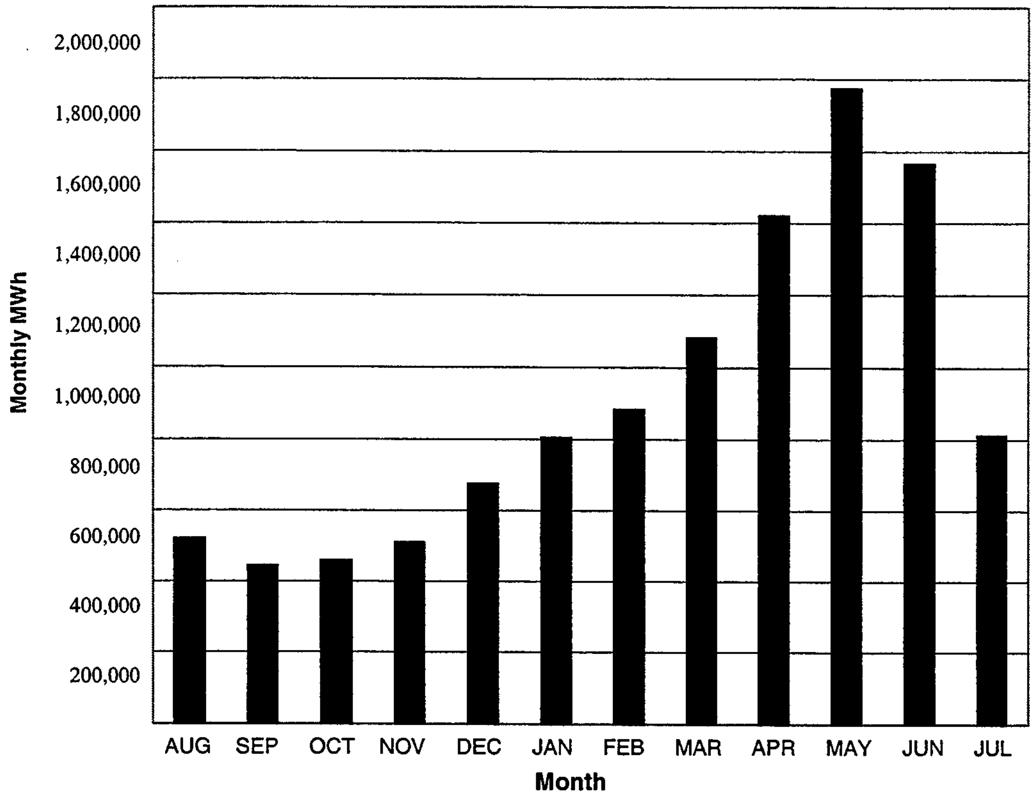
Figure 4.10-2. Combined Plant Capacity of the Four Lower Snake River Facilities

Minimum pool operations reduce the power generating head and project capacity. The maximum output of each facility is further reduced because power turbine operations are restricted to within one percent of the peak efficiency level during this period.

4.10.3.2 Average Monthly Generation

Average monthly generation estimates for the four lower Snake River facilities are presented in Figure 4.10-3. These average monthly estimates, derived using the Corps' Hydro System Seasonal Regulation Program (HYSSR), are the averages of 60 individual annual estimates that were made using actual runoff data from the water years 1929 through 1988. The variation across months reflects both the run-of-river nature of these projects and the storage capability of the upstream storage reservoirs. Upstream reservoirs are able to store some of the high spring runoff but storage capacity is relatively small compared to the annual runoff amounts. As a result, generation in the spring period far exceeds generation during the rest of the year.

Average monthly generation is relatively low from August through March with high average generation amounts never occurring from August through December and rarely between January and March. The facilities are, however, frequently operated at high output levels to follow peak demand during the winter months, but the amount of water available is often too low to allow sustained periods of high output and, therefore, average monthly generation is relatively low.



Source: DREW HIT, 1999 (Figure 2)

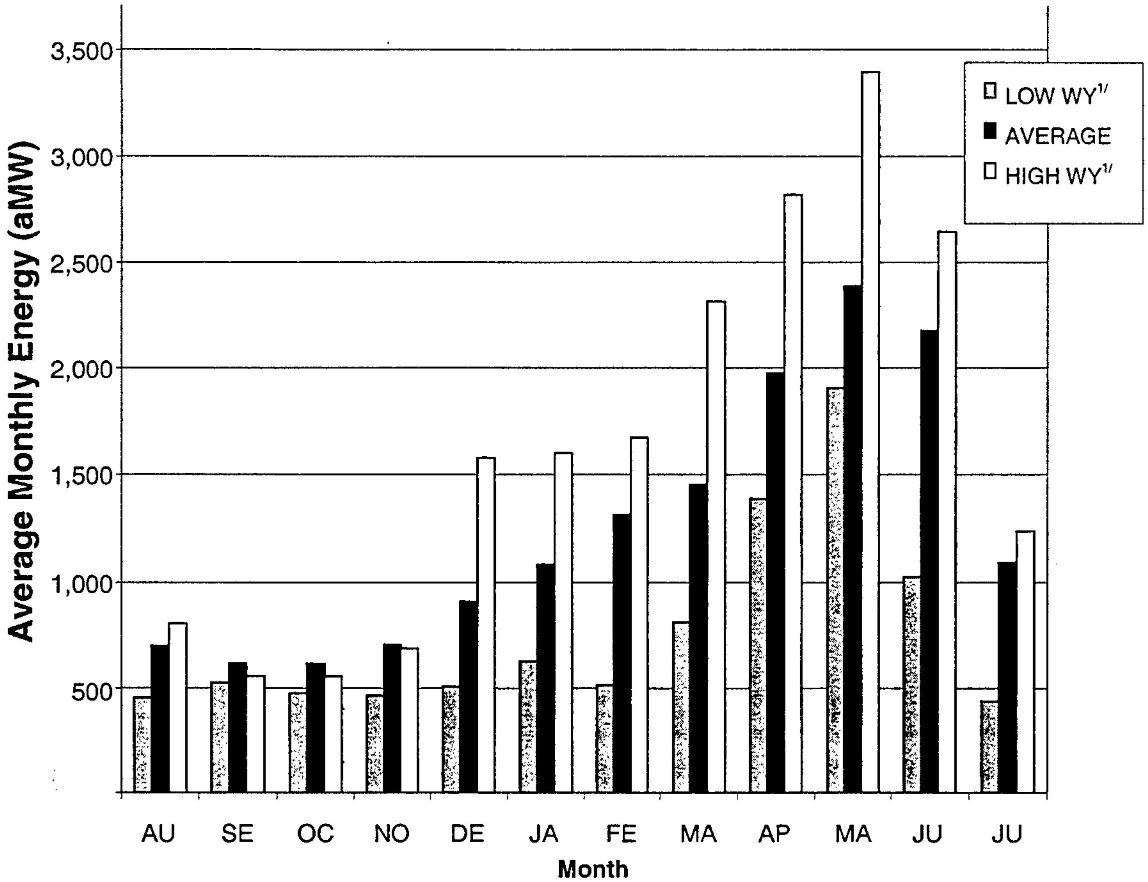
Figure 4.10-3. Average Monthly Generation by the Lower Snake River Facilities (combined)

4.10.3.3 Annual Generation

Actual monthly generation can vary significantly from year to year. Monthly generation amounts for the low water year of 1930-1931 and the high water year of 1955-1956 are compared with the 60-year average generation amounts in Figure 4.10-4. Variations from low water to high water years can be even more pronounced on a seasonal basis. In the summer months, for example, the average monthly generation of the lowest month is about 75 percent lower than the average summer monthly generation over the 60 water years of record. The highest summer monthly generation is about 160 percent larger than the monthly average. This range of variation is similar for the winter months, but considerably less during the fall and spring months.

4.10.3.4 Daily Generation and Ancillary Services

Hydropower generation at the four facilities is primarily determined by the amount of Snake River water arriving at Lower Granite because the four reservoirs have limited storage capacity and only minor tributaries flow into the reservoirs. These facilities do not have the capacity to store water on a seasonal, monthly, or even weekly basis. They can, however, shape the amount of generation throughout the day by adjusting the limited storage that is available within the top 3 to 5 feet of operating range.



Source: DREW HIT, 1999 (Figure 3)
1/ Water Year

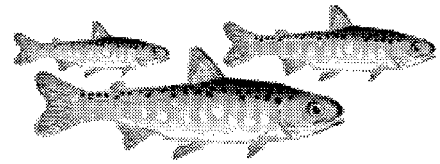
Figure 4.10-4. Annual Variation in Lower Snake River Project Average Monthly Generation

These adjustments are possible from November through March. The facilities operate within one foot of MOP for the remainder of the year in accordance with the 1995 Biological Opinion.

Generation throughout the day is shaped to meet the power demand to the extent possible given the amount of water available and other operation constraints, such as spill and flow requirements. Operation during non-peak hours is typically low to allow much higher generation during peak demand periods. A minimal level of generation is required at each facility to serve the needs of the powerhouse and the dam.

The hydropower plants in the Pacific Northwest power system provide important services on an hourly basis that are generally known as ancillary services. The WSCC has established reserve requirements for all utilities. These reserves are needed to quickly respond to emergencies in the system, such as power plant or transmission line failure. Utilities are required to have both spinning and operating reserves. Spinning reserves must be synchronized with the power system and provide immediate response. Operating reserves must be available within 10 minutes. The quick start-up ability of hydropower units provides important spinning reserves to the WSCC system. Hydropower generation can be quickly adjusted up or down to give automatic generation control that provides the required frequencies in the transmission system. Hydropower

units may also be operated as a motor, in a condensing mode, to balance the needs of the transmission system. The four lower Snake River dams are connected to the Automatic Generation Control System, which regulates electricity generation at each dam, second-by-second, to keep the WSCC system's operating frequency as close to 60 seconds per cycle as possible.



4.11 Agricultural, Municipal, and Industrial Water Uses

Water is withdrawn from the lower Snake River to support many uses. Irrigated agriculture is the dominant use, followed by municipal and industrial water supply, wildlife habitat enhancement, cattle watering, and recreational site irrigation. Wells located within one mile of the four reservoirs may be affected by the dam breaching alternative. The following discussion focuses upon these lands and uses.

4.11.1 Irrigated Agriculture

The four lower Snake River reservoirs are bordered by the counties of Asotin, Columbia, Franklin, Garfield, Walla Walla, Whitman, and Nez Perce. According to the U.S. Census of Agriculture, approximately 19 percent of the 1,695,491 acres of agricultural land in these counties was irrigated in 1997 (Table 4.11-1). Almost 97 percent of these irrigated acres are located in Franklin and Walla Walla counties, approximately 67 and 30 percent, respectively. Large river pumping stations in these two counties withdraw water for farm use from both the Columbia and Snake rivers out of the McNary and Ice Harbor pools, respectively.

Table 4.11-1. Agricultural Acreage in Southeast Washington Counties, 1997

County	Total Acres Harvested	Irrigated Land (acres)	Irrigated Land as a Percent of Total Acres Harvested by County	Irrigated Land by County as a Percent of Total Irrigated
Asotin	36,126	329	0.9	0.1
Columbia	109,607	3,565	3.2	1.1
Franklin	291,241	221,145	75.9	67.4
Garfield	114,645	693	0.6	0.2
Walla Walla	342,371	97,136	28.4	29.5
Whitman	801,501	5,469	0.7	1.7
Total	**1,695,491**	**328,337**	**19.4**	

1/ This figure is based on the six-county totals of acres harvested and acres irrigated.

Source: U.S. Census Bureau, 1997 (Agriculture)

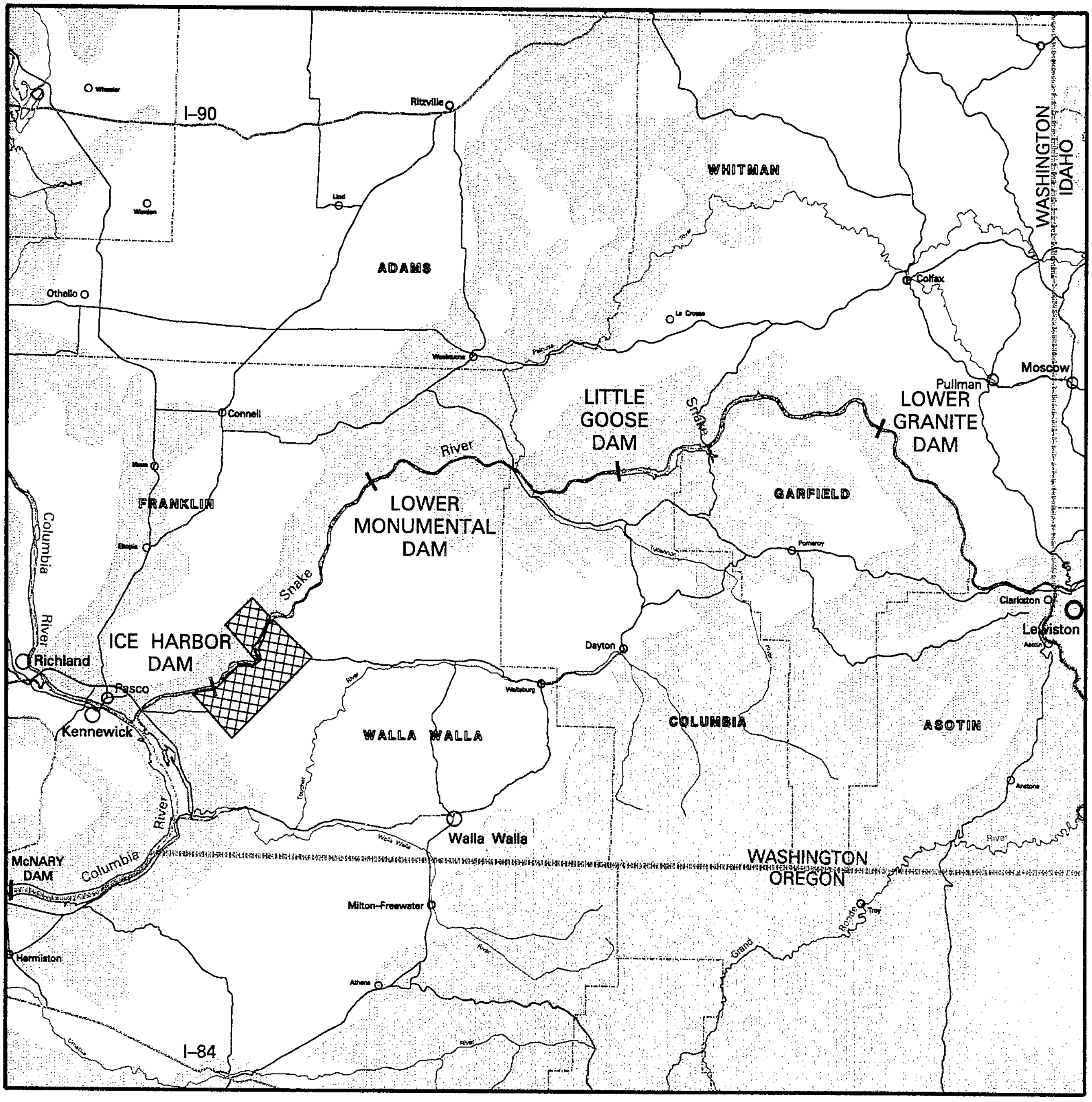
Nearly all of the Snake River water used for agricultural irrigation comes from Ice Harbor. Since the construction of Ice Harbor in the 1960s, private entities have developed the infrastructure necessary to grow irrigated crops on lands adjacent to the reservoir in Franklin County (north side) and Walla Walla County (south side). Most of the lands irrigated by the lower Snake River are located in these counties. The Corps, in 1997/1998, identified the location of 33,933 acres of the approximately 37,000 acres irrigated from Ice Harbor Reservoir. Approximately 5,693 acres were located in Franklin County, accounting for approximately two percent of irrigated agriculture in that county. The remaining 28,240 acres accounted for approximately 30 percent of irrigated agricultural lands located in Walla Walla County. The general location of the land irrigated from Ice Harbor is shown in Figure 4.11-1.

Twelve pumping stations currently use water from Ice Harbor to irrigate approximately 37,000 acres of land. Additional lands are irrigated from wells. In general, the pumping stations draw water through intake screens in the reservoir and pump the water uphill to corresponding distribution systems. The majority of the pumps are of the vertical type and a few are centrifugal pumps. Several of these pumping facilities are joint-use facilities with two or more operators using one plant site.

Many of the irrigation pumpers are large agricultural-based corporations that use pumping plants or collection systems located on the reservoir bank to pump water to lands lying adjacent to the reservoir. Irrigators pumping from the pool use natural flow rights permitted or granted by Ecology, as well as easements and permits issued by the Corps. Ice Harbor-irrigated operations are typically characterized by very large farms; high yields; high levels of irrigation management practices, which include center pivot irrigation systems; and large amounts of hired labor. Cropping on these lands is influenced by the high capital investment costs for pumping plants, above average pumping costs, and soil texture. As a result, these operations typically depend on income from high-value crops like potatoes, vegetables, and fruit, while accepting marginal returns that cover variable cost from other rotational crops like wheat and corn (Corps and NMFS, 1994).

Twelve farm operators manage 33,933 of the approximately 37,000 acres irrigated by Ice Harbor. The remaining 3,067 acres were not specifically identified by operator. Total acreage farmed, total acreage irrigated from Ice Harbor, and primary crops are identified for each farm in Table 4.11-2. Only a portion of the acreage irrigated by water withdrawn from the Ice Harbor Reservoir is in permanent crops like fruit tree orchards or vineyards. The remaining acreage by crop varies from year to year as crops are rotated. Potatoes, for example, are only grown one year in every three or four for disease control.

The estimated irrigated acreage by crop for the 1996 to 1997 growing season is provided in Table 4.11-3. Cottonwood, which is grown for pulp and paper production, is the largest crop in terms of acreage, accounting for approximately 23.2 percent of crop acreage irrigated from Ice Harbor in 1996/1997. This crop is scheduled to be harvested for the first time in the year 2000. Potatoes, the next largest crop, account for approximately 14.9 percent of the 1996/1997 irrigated acreage. Field corn and fruit tree orchards accounted for approximately 13 and 11 percent of the 1996/1997 irrigated acreage, respectively.



LAND USE & COVER

Agricultural Land

Irrigated Areas

Rangeland

Forest Land

KM 15 7.5 0 MILES 7.5 15

22,500 ACRES

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

1 : 950,400

DRAFT

Lower Snake River
Juvenile Salmon Migration Feasibility Study

Figure 4.11-1. REGIONAL LAND USE & COVER

1999

GIS Analysts & Graphic Assembly: Applied Technology Team (CENWW-PM-PD-E)
g:\regional\reg\plates\lsr\jsmeis\lsrr\lsrriuc.dgn:GISFILE PLOTTED: 07 DEC 1999

Table 4.11-2. Acreage and Crops Grown on Farms Irrigated from Ice Harbor Reservoir

Pump Stations (Ref. No.)[1/]	Total Acreage	Total Acreage Irrigated from Ice Harbor	Primary Crops
IH-1	1,500	1,500	sweet corn, onions, potatoes
IH-2	4,500	4,500	hybrid cottonwood
IH-3	12,000	9,500	potatoes, wheat, field corn, onions, sweet corn
IH-5	4,100	4,100	hybrid cottonwood
IH-6	5,000	2,200	field corn, wheat, potatoes
IH-7	2,900	2,700	grapes, apples
IH-9	540	540	apples
IH-10	4,000	1,800	apples, cherries
IH-11	6,017	4,008	apples, cherries, sweet corn, potatoes, wheat, peas, field corn
IH-12	900	900	field corn, potatoes, asparagus, wheat
IH-16	600	320	apples, cherries
IH-17	1,200	1,200	potatoes, onions
IH-18	225	165	vineyards, apples
IH-19	500	500	na
Total		**33,933**	

1/ This numbering system matches the numbering used in an earlier water supply analysis developed for the Corps (Anderson-Perry, 1991) Pump stations IH-4, IH-8 and IH-13 through IH-15 are not included in this table because water pumped via those stations is not used for agricultural production.

na – not available

Source: DREW Water Supply Workgroup, 1999

Table 4.11-3. Estimated Crop Acreage Irrigated from Ice Harbor Reservoir by Type

Crop	Percent of Irrigated Crop Acreage
Cottonwood/Poplar	23.2
Potatoes	14.9
Field Corn	13.5
Fruit Tree Orchards	11.1
Wheat	9.5
Vineyards	6.2
Sweet Corn	5.4
Onions	3.0
Undefined	13.2
Total (37,000 acres)	**100.0**

Source: DREW Water Supply Workgroup, 1999

Water from the lower Snake River also supplies private wells that are used to irrigate agricultural lands. Wells are discussed in more detail in Section 4.11.2, Municipal, Industrial, and Other Water Uses.

4.11.2 Municipal, Industrial, and Other Water Uses

Water is also withdrawn from the lower Snake River for municipal and industrial (M&I) uses and for wildlife habitat enhancement. Reservoir water also recharges groundwater supplies for agricultural wells and is used as a source of water for cattle.

There are eight M&I pump stations along the lower Snake River, all located on Lower Granite (Table 4.11-4). Water withdrawn via these stations is used for municipal water system backup, golf course irrigation, industrial process water for paper production and concrete aggregate washing, and park irrigation. The two stations owned by Clarkston Public Utility District (PUD) #1 have not been operated over the past few years and no plans exist to operate them in the immediate future. Clarkston's drinking water, supplied by the Asotin County PUD, is presently withdrawn from seven deep wells. The neighboring city of Lewiston's primary source of drinking water is the Clearwater River. It also withdraws water from six wells.

Table 4.11-4. M&I Pump Stations on Lower Granite Reservoir

Station	Use	1996 Water Usage
PUD #1	water system backup	not used in several years
PUD #1	water system backup	not used in several years
Clarkston Golf Course	golf course irrigation	460,000 gallons/day
Potlatch Corporation	mill process water and steam generation	12,287,000,000 gallons
Washington State Parks	park irrigation	12,813,000 gallons
Idaho State Parks	park irrigation	no meter
Whitman County Park	park irrigation	540,000 gallons
Atlas Sand & Rock	concrete aggregate washing	not available
Lewiston Golf Club	golf course irrigation	1.0-1.5 million gallons/day in June-August

Source: DREW Water Supply Workgroup, 1999

Water is also withdrawn from the lower Snake River to irrigate vegetation for Habitat Management Unit (HMU) wildlife areas. HMUs were established along the lower Snake River to compensate for wildlife habitat lost as a result of inundation by the Snake River dams. There are currently eight HMUs being irrigated by 11 surface water pumping plants and two HMUs being irrigated by well-supplied water (Table 4.11-5). A list of all irrigated and non-irrigated HMUs on the lower Snake River is presented in Section 4.6. These irrigated HMUs cover approximately 960 acres of land, the majority of which is located on Ice Harbor Reservoir. Irrigation is typically used to promote vegetation growth for wildlife cover and feeding.

Table 4.11-5. Irrigated HMUs Along the Lower Snake River

HMU	Water Supply Source
Big Flat	River Intake, Pump Stations
Lost Island	River Intake, Pump Stations
Hollebeke	River Intake, Pump Stations
Skookum	River Intake, Pump Stations
Fifty-five Mile	River Intake, Pump Stations
Ridpath	Ground Water Well
New York Bar	River Intake, Pump Stations
Swift Bar	River Intake, Pump Stations
John Henley	Ground Water Well
Chief Timothy	River Intake, Pump Stations

Source: Annex J of Technical Appendix D, Natural River Drawdown Engineering

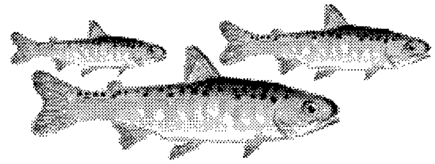
Wells located within one mile of the lower Snake River could be affected by a natural drawdown. State water well reports indicate that approximately 225 wells are located within one mile of the lower Snake River. Approximately 53 percent of these wells are used for either domestic or irrigation purposes. The uses and locations of these wells are summarized by county in Table 4.11-6.

Table 4.11-6. Well Reports by Use and County (Number of Wells)

Use	Asotin	Columbia	Franklin	Garfield	Walla Walla	Whitman	Total	% of Total
Domestic	40	2	9	3	12	12	**78**	**35**
Industrial				1	2	3	**6**	**3**
Irrigation	7	1	18	1	9	4	**40**	**18**
Multiple	5	5	4	4	3	4	**25**	**11**
Municipal	7				2	1	**10**	**4**
Other	2		9	2	2	1	**16**	**7**
Test Well	3		4			2	**9**	**4**
Not Reported	3	4	5	2	15	12	**41**	**18**
Total	**67**	**12**	**49**	**13**	**45**	**39**	**225**	
% of Total	**30**	**5**	**22**	**6**	**20**	**17**	**100**	

Source: DREW Water Supply Workgroup, 1999

Cattle watering corridors provide access across government property for cattle to water from the lower Snake River reservoirs. These corridors are fenced off down to the river bank. Sixty-nine corridors have been identified along the Snake River. Twenty-nine of these corridors are located on Lower Monumental. Twenty-one cattle watering corridors are located on Little Goose, with the remaining 19 corridors divided between Ice Harbor (11) and Lower Granite (8).



4.12 Land Ownership and Use

4.12.1 Regional Land Use

About two-thirds of land in the Columbia River Basin is publicly owned. Public lands in the Columbia River Basin are managed by Federal government agencies, state and local governments, and Indian tribes. Federal lands, including Indian reservations under Federal and tribal jurisdiction, account for approximately 55 percent of the total land area. These lands include national forests, National Park System lands, Bureau of Land Management (BLM)-managed resource lands, national wildlife refuges, and Federal reservations used for military or related purposes. The Umatilla National Forest, the closest national forest to the lower Snake River, is located approximately 12 miles southwest at its closest point. BLM lands are concentrated in southern Idaho and southeastern Oregon. The Hells Canyon National Recreation Area begins 35 miles upstream of the project area and encompasses a 168-mile-long corridor along the Snake River. Idaho, Oregon, and Washington all have sizable acreages of state-owned lands, which are typically managed for income from timber, range, and mineral resources, but also provide wildlife habitat and recreation. The acreage of state lands near the lower Snake River dams is relatively small but includes a number of wildlife and park units. Indian reservations in the vicinity of the lower Snake River are discussed in Section 4.8, Native American Indians.

Forest is the predominant land cover in the Pacific Northwest, accounting for approximately 49 percent of land cover in the region. This proportion is, however, noticeably less in the Columbia River Basin. The rangeland proportion for the Columbia River Basin is somewhat higher than for the region as a whole because it contains most of the drier interior zones within the region. The highest concentrations of rangeland are in Oregon and Idaho, where range covers most of the Snake River Plain and the southeastern quadrant of Oregon. Over 60 percent of rangelands in the region are Federally-owned, with two-thirds of that administered by BLM. Cropland accounts for about 12 percent of regional land cover. The proportion located in the Columbia River Basin is higher, especially in Washington where cropland accounts for 19 percent of the total state area, most of which is located in eastern Washington. Urban land uses, concentrated in the Portland-Vancouver, Spokane, Boise, and Eugene-Springfield areas, account for about 2 percent of regional land use. Regional land use and cover is shown

in Figure 4.11-1 in Section 4.11, Agricultural, Municipal, and Industrial Water Uses. This map emphasizes rangeland, forest land, and agriculture. Urban land uses are not specifically identified.

The potentially affected lower Snake River region was divided into three subregions—downriver, reservoir, and upriver—as part of the regional economic analysis developed for this FR/EIS (see Technical Appendix I, Economics). The counties that comprise these subregions and together form the lower Snake River region study area presented in Table 4.14-1 in Section 4.14, Social Resources (see also Figure 4.14-1). These subregions separate the lower Snake River study area into three functional geographic areas based on the type of likely impacts if dam breaching were to occur. This is discussed further in Section 4.14.1, Regional Demographics and Employment.

Land use in the reservoir subregion is predominantly agricultural. Agricultural land uses comprise about 80 percent of land cover in the seven-county area (Table 4.12-1). Cropland is the dominant agricultural land use in this subregion (Table 4.12-2). Agricultural land tenure in the study area has undergone significant change in recent decades. All three subregions have experienced a decrease in the number of farms and an increase in average farm size. The downriver subregion has the largest number of farms and acres farmed of the three subregions. Between 1959 and 1992, this subregion lost 1,279 farms or 18.4 percent of the 1959 total (Figure 4.12-1). The reservoir and upriver subregions over this period lost 1,544 and 1,537 farms, respectively, 34.1 and 32.6 percent of their 1959 totals (Figures 4.12-2 and 4.12-3).

Table 4.12-1. Land Use in the Reservoir Subregion

County	Land Area (Acres)	BLM Acres	BLM %	Forest Service Acres	Forest Service %	Wilderness Acres	Wilderness %	Non-Federal Timberland Acres	Non-Federal Timberland %	Farms Acres	Farms %
Adams	1,235,027	481	0.0	0	0.0	0	0.0	0	0.0	996,742	80.7
Asotin	410,041	10,422	2.5	53,797	13.1	2,634	0.6	26,000	6.3	274,546	67.0
Columbia	558,046	519	0.1	159,500	28.6	80,472	14.4	49,000	8.8	304,928	54.6
Franklin	809,850	18,788	2.3	0	0.0	0	0.0	0	0.0	670,149	82.7
Garfield	463,746	433	0.1	95,467	20.6	28,035	6.0	9,000	1.9	325,472	70.2
Walla Walla	831,508	630	0.1	2,433	0.3	0	0.0	18,000	2.2	710,546	85.5
Whitman	1,393,670	1,294	0.1	0	0.0	0	0.0	9,000	0.6	1,404,289	100.8[1/]
Total	**5,701,888**	**32,567**	**0.6**	**311,197**	**5.5**	**111,141**	**1.9**	**111,000**	**1.9**	**4,686,672**	**82.2**

1/ This presumably reflects inconsistencies in the databases compiled by McGinnis et al., 1997. Source: McGinnis et al., 1997

Table 4.12-2. Agricultural Land Use in the Reservoir Subregion

	Adams	Asotin	Columbia	Franklin	Garfield	Walla Walla	Whitman
Total Farmed Acres	996,742	274,546	304,928	670,149	325,472	710,546	1,404,289
Cropland	781,122	85,202	180,083	457,795	197,054	604,519	1,132,001
Pasture/Range	na	164,217	102,789	na	118,395	61,183	237,375
Woodland	3,068	22,696	15,023	3,950	6,158	20,101	20,985
Other	na	2,431	7,033	na	3,865	24,743	13,928
Avg. Farm Size	1,656	1,933	1,596	782	1,750	954	1,262
Number of Farms	602	142	191	857	186	745	1,113

na = not available. Source: McGinnis et al., 1997

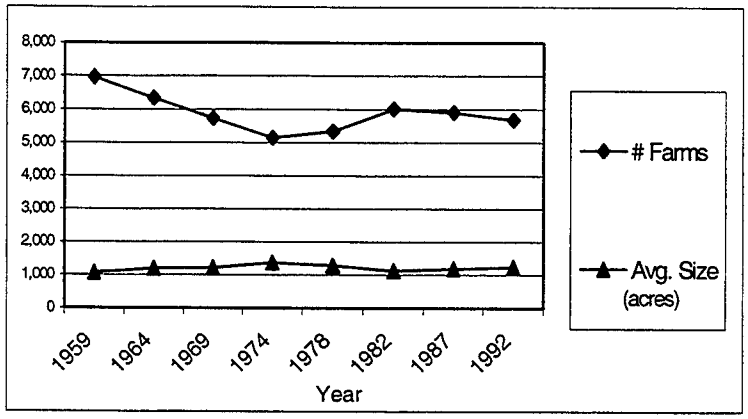


Figure 4.12-1. Number and Average Size of Farms in the Downriver Subregion, 1959-92

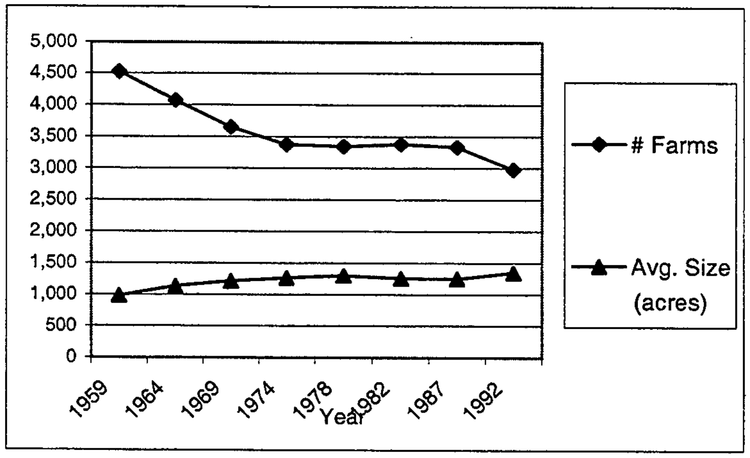


Figure 4.12-2. Number and Average Size of Farms in the Reservoir Subregion, 1959-92

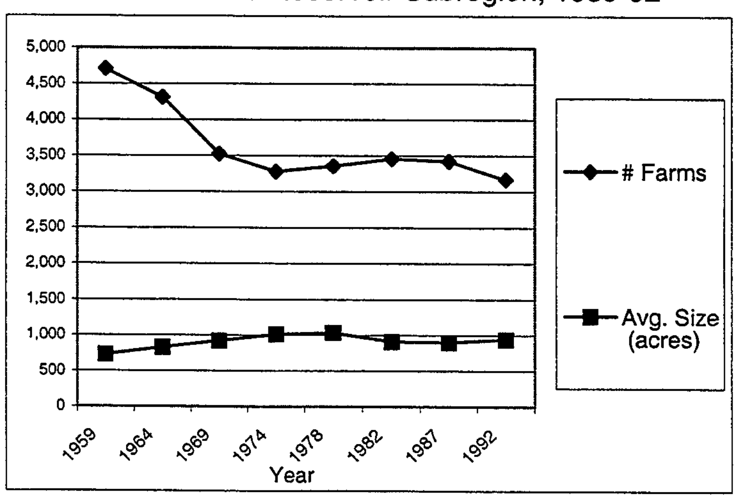


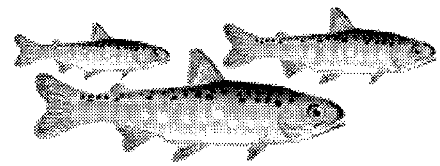
Figure 4.12-3. Number and Average Size of Farms in the Upriver Subregion, 1959-92

This has not, however, been a simple linear decline. Rather, all three subregions experienced both increases and decreases in the number of farms between 1959 and 1992 (Figures 4.12-1 through 4-12-3). The average size of farms also fluctuated over this period. In general, the trend has been toward increasing farm size in all three subregions.

4.12.2 Lower Snake River Corridor

Any direct effects from the proposed action would be felt within the immediate river corridor and primarily on lands adjacent to the river or reservoirs. The lower Snake River corridor is almost entirely in private ownership. The only public lands in the immediate river vicinity are Federal project lands administered by the Corps and isolated parcels owned by the State of Washington. The key land units leased to the state are Chief Timothy, Central Ferry, and Lyons Ferry state parks.

The lower Snake River reservoirs generally fill the width of the canyon, leaving relatively little flat land for cultivation. Grassland range is the predominant land cover along the approximate 140-mile-long river corridor. There are some relatively small and isolated cropland areas on the valley floor and river terraces, particularly toward the western end of the river corridor. There are also approximately 37,000 acres irrigated from, and located adjacent to, Ice Harbor Reservoir. The Lewiston-Clarkston area has a significant concentration of urban development at the eastern end of the corridor, including residential, industrial, and commercial uses. Isolated pockets of developed land are located in small communities, including Almota, Riparia, and Windust. Unlike many reaches of the Columbia-Snake River System, much of the lower Snake River is not paralleled by highways.



4.13 Recreation and Tourism

4.13.1 Recreation

The lower Snake River and its reservoirs, dams, and adjacent shorelines provide numerous opportunities for recreation. Water-based recreational activities include fishing, water-skiing, boating, windsurfing, and swimming. Many boat launch ramps, beaches, marinas, and other facilities have been developed to support these activities. Land-based activities such as picnicking, camping, and hiking are also popular and take place at facilities along the reservoirs. Recreational sites on the Lower Snake River Project reservoirs represent the bulk of water-oriented recreational opportunities in southeastern Washington. Much of the following recreation and tourism discussion is drawn from earlier studies of the Columbia-Snake River System (BPA et al., 1995; Corps and NMFS, 1994). Other sources are noted as appropriate.

4.13.1.1 Recreation Management

Recreation use and development at Ice Harbor, Lower Monumental, Little Goose, and Lower Granite are authorized under Federal legislation, including the Federal Water Project Recreation Act of 1964 and the Flood Control Act of 1944. Under these laws, the Corps provides recreation opportunities at the lower Snake River dams. The Corps cooperates with the state park departments in Idaho and Washington and a variety of other local entities, such as counties, cities, and port districts, to maintain a system of water-related recreation facilities. These include boat launch ramps, swimming beaches, marinas, campgrounds, picnic areas, and interpretive sites.

Recreation Facilities and Activities

There are 33 developed recreation sites adjacent to the lower Snake River reservoirs. These include 29 boat launch ramps with 59 launch lanes, 5 moorage and marina facilities, 9 campgrounds with approximately 435 individual campsites, and 49 day-use facilities (Table 4.13-1) (Corps, 1998c). Virtually all sites provide recreation opportunities that either depend on water or are enhanced by the proximity of water. Most of these sites are located in rural areas removed from population centers (Figure 4.6.4 in Section 4.6, Terrestrial Resources). Exceptions include the sites located on

Table 4.13-1. Lower Snake River Recreation Facilities

Recreation Site	Boat Ramps	Boat Launch Lanes	Boat Moorage Spaces	Picnic/Group Shelters	Campsites
Lake Sacajawea (Ice Harbor Pool)					
North Shore Ramp	1	2			
Charbonneau Park	1	4	45	7	54
Levey Park	1	2		8	
Fishhook Park	1	2	20	8	41
Windust Park	1	1		2	30
Matthews Recreation Area	1	1			
Lake West (Lower Monumental Pool)					
Devils Bench	1	2			
Ayers Boat Basin	1	2		2	
Lyons Ferry Marina	1	1			
Lyons Ferry State Park	1	2		4	52
Texas Rapids	1	1		3	
Riparia					
Lake Bryan (Little Goose Pool)					
Little Goose Landing	1	1			
Central Ferry State Park	1	4			62
Garfield County Ramp	1	2			
Willow Landing	1	1			
Illia Landing	1	1			
Illia Dunes					
Boyer Park and Marina	1	3	100	3	28
Lower Granite Lake (Lower Granite Pool)					
Offield Landing	1	1			
Wawawai County Park				4	9
Wawawai Landing	1	1			
Blyton Landing	1	1			
Nisqually John Landing	1	1			
Chief Timothy State Park	1	4			66
Hells Canyon Resort (Redwolf Marina)	1	2	137		
Greenbelt Ramp	1	2	3		
Southway Ramp	1	2			
Swallows Park	1	4		2	
Hells Gate State Park	1	6	1/	6	93
Chief Looking Glass Park and Marina	1	2			
Clearwater Park					
North Lewiston Ramp	1	1			

Source: Corps, 1998c
1/ Data unavailable. To be updated with current information

Ice Harbor, which are close enough to be used by residents of the Tri-Cities, and sites located on Lower Granite near the Lewiston-Clarkston area.

Recreational sites located at the dams and along the lower Snake River vary greatly in terms of size, type of facilities, level of development, features, management, use, and accessibility. The larger, more intensively developed recreation sites often have a variety of facilities to support different activities. Many provide boat launch ramps, docks, marinas, campgrounds, and day-use areas with developed swimming and picnicking facilities. These sites typically have paved boat launch lanes and parking areas, restrooms with running water, retail and service concessions, landscaping, and irrigated lawns. Several of the larger developed facilities along the river were developed by the Corps and are operated by counties or port districts under lease. The smaller recreation sites along the river are less developed and support one or two key uses, typically water access via boat launch ramps. In addition to the developed facilities, there are many informal sites that simply provide access to the water or to publicly-owned lands.

Of the four Lower Snake River Project reservoirs, Lower Granite is the most heavily developed for recreation (Table 4.13-1). Recreation sites associated with Lower Granite are concentrated in proximity to the Lewiston-Clarkston area. These sites are mostly urban in character and use and are important contributors to the quality of life of the two cities. The riverside parks that lie between Lower Granite and nearby city neighborhoods are popular for water-oriented activities such as boating and swimming. However, the most heavily used recreational facilities are Lewiston Levee Parkway and the extensive riverside trail systems located at Swallows Park and Greenbelt Park. Two marinas, the privately operated Hells Canyon Resort and the state-operated Hells Gate State Park, are located in the Lewiston-Clarkston area and serve local and transient boats. Private, 60-foot-plus boats were reported using Clarkston shorelines for moorage in 1994 (Corps and NMFS, 1994). In addition, several companies operating out of the Lewiston-Clarkston area offer jet boat tours of Hells Canyon upriver from Lower Granite.

Ice Harbor has four major parks and two boat launch sites. All of the sites are relatively isolated. The three sites farthest downstream (Levey Park, Ice Harbor, and Charbonneau) are the closest to an urbanized area. The three sites are located within 10 to 15 miles of Pasco and Kennewick. Recreation development at Lower Monumental is more limited, largely due to the high basalt cliffs that surround the project. The six developed recreational sites located at Lower Monumental range from a simple fishing access ramp to Lyons Ferry State Park to the Port of Columbia's Lyons Ferry Marina. Rugged terrain has also limited development at Little Goose. Developed sites at Little Goose include two that are leased from the Corps by the State of Washington and one that is leased by the Port of Whitman County (Table 4.13-1).

Water-oriented activities such as fishing, boating, and water skiing take place at all four reservoirs. Swimming occurs at all four reservoirs and is actually the most popular activity at Little Goose. Land-based activities such as picnicking, hiking, and camping are popular to varying degrees at different projects. At Lower Granite, trail use is the most popular activity due to the high use of trails at Lewiston-Clarkston riverside parks. Table 4.13-2 displays visitor distribution activity for each dam and reservoir.

Table 4.13-2. Visitor Distribution by Activity at the Lower Snake River Reservoirs (%)

Activity	Ice Harbor	Lower Monumental	Little Goose	Lower Granite
Boating	20	22	28	26
Camping	14	9	13	3
Fishing	38	27	25	18
Hunting	1	3	1	0
Picnicking	22	25	32	13
Sightseeing	24	13	26	15
Swimming	14	12	32	13
Water-skiing	8	4	5	3
Other	38	43	46	61

Source: Corps, 1998d

4.13.1.2 Visitation

Recreational visits vary considerably among the four dam facilities. Lower Granite is the most heavily used, with 1,144,800 visitors in fiscal year 1998. Lower Monumental is used least, with 157,700 visitors over the same period. Visitation to Lower Snake River Project recreational facilities is measured in recreation days. A recreation day is defined as the presence of one person on an area of land or water for the purpose of engaging in one or more recreational activities during a portion or all of a 24-hour period. The number of visits to the Lower Snake River Project recreational facilities in fiscal year 1998 is displayed by facility and reservoir in Table 4.13-3.

Visitation also varies considerably by season, with use heavily concentrated in the summer. While pool elevations and river flows can have an influence, weather is the most important factor determining the seasonal use and demand for water-related outdoor recreation in the basin. The primary recreational activities, including sight-seeing, fishing, boating, and water-skiing, occur year-round at most of the dams and reservoirs in the Columbia River Basin. However, the peak periods of use for all activities occur during the warm, dry summer months.

Annual visitation typically builds slowly, beginning in April and continuing in May, with visits tending to increase rapidly from the end of May through June and July, peaking in August. The Lower Snake River Project facilities typically receive over 50 percent of average annual visitation from May through August. Peak recreation season roughly corresponds to the period between Memorial Day and Labor Day weekends. Local weather conditions are most amenable for water-dependent and water-related recreation activities, most students are out of school for the summer, and families tend to take their vacations during this period. Visitation generally begins to decline in September.

Many outdoor recreationists visiting the four dams and reservoirs live in relatively close proximity. A survey of outdoor recreationists, excluding anglers, was conducted at the four reservoirs between June 24, 1997 and November 29, 1997. This survey found that 52 percent of 367 respondents resided within 50 miles of the reservoir, with approximately 26 percent living within 20 miles (AEI, 1999). A similar survey

Table 4.13-3. Visitation at Recreation Areas

Project/Recreation Area	Number of Visitors (FY98)
Ice Harbor	
Charbonneau Park	71,800
Fishhook Park	48,800
Ice Harbor Dam	250,500
Levey Park	14,200
Windust Park	21,700
Total	***437,700***
Lower Monumental	
Ayer Boat Basin	2,800
Lower Monumental Dam	44,500
Lyons Ferry State Park	73,900
Lyons Ferry Marina	22,300
Texas Rapids	7,900
Total	***157,700***
Little Goose	
Boyer Park	85,300
Central Ferry State Park	54,800
Illia Landing	4,000
Little Goose Dam	52,900
Willow Landing	3,200
Total	***222,700***
Lower Granite	
Chief Looking Glass	27,900
Chief Timothy State Park	104,100
Clearwater Park	24,000
Clearwater Ramp	20,900
Hells Canyon Reservation	43,700
Hells Gate State Park	90,400
Lewiston Levee	269,900
Lower Granite Dam	33,400
North Shore	37,500
Southway Ramp	108,300
Swallows Park	371,400
Wawawai County Park	24,300
Total	***1,144,800***
Combined Total (all four projects and associated recreation areas)	**1,962,900**

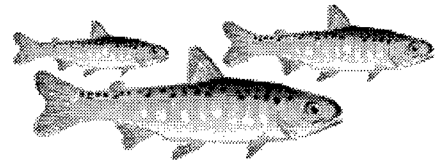
Source: Corps, 1998e

conducted of anglers found that over 70 percent of 576 respondents lived within 50 miles of the reservoirs, with approximately 41 percent living within 20 miles (AEI, 1999).

4.13.2 Tourism

Increasing numbers of tourists are drawn to the lower Snake River, the recreational amenities available along the river, and the four project dams and reservoirs. Tourism contributes to the economies of the communities located along the river. Three of the four Lower Snake River Project facilities have a visitors center where people can learn about power production, navigation, archaeology, local geology, the history of the river, recreation opportunities, and fish transportation and passage facilities. The dams and associated visitors centers are themselves important recreational sites, receiving significant numbers of visitors throughout the year (Table 4.13-3). Tourists also visit the fish hatchery and associated interpretive facilities at Lyons Ferry Hatchery, which is operated by the State of Washington.

Three commercial cruise lines operate four cruise ships on the lower Columbia and Snake rivers. Week-long tours regularly depart Portland, travel upriver to Clarkston, and then return to Portland. The Columbia-Snake River System cruises are generally scheduled from the beginning of April through the first week of June, and again from September through the first half of November. In between the spring and fall river cruise periods, the cruise ships operate in Alaskan waters. Passengers pay an average of about $2,000 each for 8-day, 7-night trips on the lower Columbia and Snake rivers. These trips stop at several communities and other points of interest along the way and about 95 percent of all passengers take an optional side trip from Clarkston up Hells Canyon via jet boat. Roughly 50,000 passengers per season are accommodated on these cruises, with this total distributed fairly evenly between the spring and fall cruise periods.



4.14 Social Resources

The following discussion is divided into three main sections. Section 4.14.1 provides an overview of regional demographics and employment. Section 4.14.2, which addresses potentially affected communities, provides a general overview of the communities in the region in terms of population and economic diversity. It also outlines the focus community selection process and introduces the typology of communities developed for this FR/EIS by the University of Idaho (UI). Section 4.14.3 addresses low income and minority populations and provides information on race and poverty.

4.14.1 Regional Demographics and Employment

The social resources of communities located in the vicinity of the lower Snake River would be affected by the proposed alternatives. For the purposes of analysis, the potentially affected lower Snake River region was divided into three subregions: upriver, reservoir, and downriver. The counties that comprise these subregions and the combined lower Snake River study area are identified in Table 4.14-1 and Figure 4.14-1. These subregions separate the lower Snake River study area into three functional geographic areas based on the type of likely impacts if dam breaching were to occur. The downriver subregion defines a region that would be the terminus of barge transportation if the four lower Snake River dams were breached. The reservoir subregion, which consists of those counties that adjoin the four lower Snake River reservoirs, would see changes in barge transportation and recreation. The upriver subregion would lose barge transportation but gain increased recreation. The three subregions are used to evaluate localized impacts. Other potential impacts associated with this study that would have more regional effects were analyzed at the state level.

Table 4.14-1. Regional Analysis Study Area by State and County

Downriver Subregion	Reservoir Subregion	Upriver Subregion
Oregon	**Washington**	**Idaho**
Gilliam	Adams	Clearwater
Hood River	Asotin	Custer
Morrow	Columbia	Idaho
Sherman	Garfield	Latah
Umatilla	Walla Walla	Lemhi
Wasco	Whitman	Lewis
		Nez Perce
Washington		Valley
Benton		
Franklin		
Klickitat		**Oregon**
Skamania		Wallowa

The following sections discuss regional trends in employment, income, population, and age. For ease of presentation, trends are discussed at the subregional level. Reference is made to individual counties, as appropriate.

4.14.1.1 Employment

The economy of the Pacific Northwest has undergone substantial change over the past three decades. From 1970 to 1995, the number of jobs in the Pacific Northwest grew at a faster rate than the nation as a whole. The nation saw a 64 percent increase in the absolute number of jobs while employment in Washington, Oregon, and Idaho more than doubled over the same time period. Jobs in the 25 county study area increased by 74 percent over this period, a rate slower than the regional average but higher than the nation as a whole (Table 4.14-2). The total number of jobs in both the region and the study area has increased even as employment in historically important job sectors such as logging, mining, and farming and ranching has declined or remained stagnant. In 1970, resource-based industries such as lumber and wood products, paper, agricultural products, and fisheries accounted for half of the region's manufacturing employment. Despite the relative decline of these sectors, they are still important parts of the region's economic base, especially in small communities where they may be the dominant source of employment. The largest manufacturing sectors in the region are now the high technology and transportation equipment sectors. In addition, the non-manufacturing or service sector accounts for the bulk of employment in the region (IEAB, 1999). These trends are also evident in the 25-county lower Snake River area.

Employment in the study area increased in nearly all sectors between 1970 and 1995. Exceptions include the farm and military sectors, both of which experienced an absolute decline in the numbers employed. Employment in service industries has increased significantly. Service industry increases include gains in recreation and tourism, business, education, and management and engineering services. The study area also experienced

ECONOMIC SUBREGIONS

Down River

Reservoir

Up River

FOCUS COMMUNITIES

LOWER SNAKE RIVER DAMS

BOUNDARIES

State

County

KM 70 35 0 MILES 35 70

490,000 ACRES

1 : 53,222,400

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

DRAFT

Lower Snake River
Juvenile Salmon Migration Feasibility Study

Figure 4.14–1.
REGIONAL ANALYSIS

1999

GIS Analysts & Graphic Assembly: Applied Technology Team (CENWW-PM-PD-E)
g:\regional\reg\plates\lsr\jsmeis\lsrg\lsrgea.dgn:GISFILE PLOTTED: 07 DEC 1999

Table 4.14-2. Employment in the 25 Study Counties, 1970-95

	1970		1995		Change 1970-95	
Total full- and part-time employment	183,686		318,740		135,054	73.5%
Farm employment	29,417	16.0%	27,625	8.7%	-1,792	-6.01%
Nonfarm employment	154,269	84.0%	291,115	91.3%	136,846	88.7%
Ag. serv., forestry, fishing, and other	1,894	1.2%	7,721	2.7%	5,827	308%
Mining	430	0.3%	738	0.3%	308	71.6%
Construction	8,238	5.4%	14,715	5.1%	6,477	78.6%
Manufacturing	24,343	15.9%	30,955	10.8%	6,612	27.2%
Transportation and public utilities	7,745	5.0%	11,726	4.1%	3,981	51.4%
Wholesale trade	4,580	3.0%	10,540	3.7%	5,960	130%
Retail trade	26,732	17.4%	53,079	18.6%	26,347	98.6%
Finance, insurance, and real estate	8,184	5.3%	13,290	4.6%	5,106	62.4%
Services	32,948	21.5%	83,390	29.2%	50,442	153%
Government and government enterprises	38,376	25.0%	59,740	20.9%	21,364	55.7%

Source: U.S. Bureau of Economic Analysis, 1999

large gains in the retail trade and state and local government sectors. Growth is also evident in the wholesale trade and the finance, insurance, and real estate sectors (Table 4.14-2).

These patterns appear to be broadly similar across all three subregions, with absolute increases in all sectors, with the exception of the farm and military sectors in the reservoir and upriver subregions and the mining sector in the downriver subregion. Employment in the farm sector declined by 14.1 and 20.9 percent in the reservoir and upriver subregions, respectively. The downriver subregion, by contrast, experienced a 9 percent increase in farm employment. Comparing two snapshots of employment–1970 and 1995—may mask employment fluctuations in the intervening period. Farm employment, for example, fluctuated substantially over this period in all three subregions.

Total full-time and part-time employment increased most rapidly in the downriver subregion over the study period, with a 99 percent increase in the number employed compared to 47.5 and 66.4 percent increases in the reservoir and upriver subregions, respectively. The downriver subregion labor force was already larger than that in the reservoir and upriver subregions in 1970. As a result, growth trends viewed at the study area level largely reflect those in the downriver subregion. The downriver subregion experienced larger relative and absolute employment gains than the other two subregions in almost all sectors. This is particularly noticeable in the services, retail trade, and state and local government sectors.

The 1995 employment profiles of the three subregions are fairly similar (Table 4.14-3). The downriver subregion, however, has a much larger portion of total employment concentrated in the services sector, 34.4 percent compared to 25.2 and 23.5 percent in the reservoir and upriver subregions, respectively. The reservoir and upriver subregions, in turn, have a larger concentration of employment in the government and government enterprises sector.

Table 4.14-3. Employment by Subregion, 1995

	Downriver		Reservoir		Upriver	
Total full- and part-time employment	151,124		92,535		75,081	
Farm employment	12,785	8.5%	10,668	11.5%	4,172	5.6%
Nonfarm employment	138,339	91.5%	81,867	88.5%	70,909	94.4%
Ag. serv., forestry, fishing, and other	4,044	3.0%	2,537	3.1%	1,140	1.6%
Mining	44	0.0%	15	0.0%	679	1.0%
Construction	6,863	5.0%	3,604	4.5%	4,248	6.1%
Manufacturing	14,692	10.8%	8,110	10.1%	8,153	11.8%
Transportation and public utilities	5,554	4.1%	3,173	3.9%	2,999	4.3%
Wholesale trade	3,990	2.9%	4,563	5.7%	1,987	2.9%
Retail trade	25,202	18.5%	13,795	17.1%	14,082	20.3%
Finance, insurance, and real estate	5,929	4.4%	3,751	4.6%	3,610	5.2%
Services	46,783	34.4%	20,303	25.2%	16,304	23.5%
Government & government enterprises	22,804	16.8%	20,836	25.8%	16,100	23.2%

Source: U.S. Bureau of Economic Analysis, 1999

4.14.1.2 Income

Sources of Personal Income

The past three decades have seen a notable increase in non-labor income as a share of total income in the Pacific Northwest region. Non-labor income includes dividends, interest and rent, and transfer payments. Transfer payments include private pensions and government payments like social security. Non-labor income has also increased as a shared total income in the 25-county lower Snake River study area. From 1970 to 1995, transfer payments as a percentage of total income increased from 10.9 to 18.2 percent. Dividends, interest, and rent also increased but at a more modest rate of 3.9 percent. This increase in the proportion of personal income received from non-labor sources suggests that a larger portion of the population is living off its capital, a trend generally associated with an aging population. Farm income declined both in absolute terms and as a share of total income over this period, decreasing from 13.8 to 3.4 percent of total income (Table 4.14-4).

Table 4.14-4. Sources of Personal Income in the 25-County Study Area

	1970	1995	Change 1970 to 1995
Nonfarm Income	62.31	61.45	-0.86
Farm Income	13.76	3.44	-10.32
Dividends, Interest and Rent	13.08	16.94	3.86
Transfer Payments	10.86	18.18	7.32
Total	**100.01**	**100.01**	

Per Capita Income

The states of Washington, Oregon, and Idaho had respective per capita incomes of $23,974, $21,915, and $19,199 in 1995. U.S. per capita income in 1995 was $23,359. Per capita income in the 25-county study area was $17,570 in 1995, with little variation across the three subregions (Table 4.14-5). Viewed in 1995 dollars, per capita income increased in the study area and all three subregions during the 1970s and ranged in 1980 from $15,732 in the upriver subregion to $21,287 in the downriver region. Since 1980, however, this figure has declined in both the downriver and reservoir subregions, while the upriver subregion has experienced modest increases (Table 4.14-4). In 1995 per capita income in the 25 study area counties ranged from $14,576 in Morrow County, Oregon in the downriver subregion to $22,058 in Benton County, Washington also in the downriver subregion.

Table 4.14-5. Per Capita Income by Subregion, 1970-95 (1995 dollars)

	1970	1980	1990	1995
Downriver	15,490	21,287	19,167	17,332
Reservoir	15,906	19,566	18,916	17,760
Upriver	13,173	15,732	17,590	17,661
Study Area	14,772	18,805	18,529	17,570

Source: U.S. Bureau of Economic Analysis, 1995

4.14.1.3 Population

The majority of the area surrounding the lower Snake River is sparsely populated. The total population of the study area was approximately 582,119 in 1995 (Table 4.14-6). Population is distributed unevenly among the 25 counties and three subregions that comprise the study area. The downriver subregion, which extends from the confluence of the Snake and Columbia rivers to below Bonneville Dam, is the most populated, accounting for 278,429 or approximately 48 percent of the 25 county study area's 1995 population (Table 4.14-6). More populated counties in the study area include Benton (133,070) and Walla Walla (52,982) counties in Washington, and Umatilla County in Oregon (64,040). These counties accounted for 22.9 percent, 9.1 percent, and 11.0 percent of the 1995 study area population, respectively.

Population in Washington, Oregon, and Idaho increased at rates ranging from two to three times the national average during the 1970s (Table 4.14-6). The 25-county study area also grew rapidly over this period, increasing by 102,448 people or 24.8 percent. Most study area counties reported population increases during this decade, but for the most part these increases were smaller than their respective state averages. The downriver subregion grew most rapidly (39.7 percent) and also experienced the highest absolute population increase due in part to expanding irrigated agriculture and increased activity at the Hanford Reservation. The Hanford Reservation is located in Benton County, Washington in the downriver subregion. This county accounted for 41 percent of the total study area population increase during this decade.

Table 4.14-6. Population by Subregion, 1970-95

	Total Population				Percent Change		
	1970	**1980**	**1990**	**1995**	**1970-80**	**1980-90**	**1990-95**
Downriver	172,712	241,361	246,560	278,429	39.7	2.2	12.9
Reservoir	139,055	159,178	162,167	178,739	14.5	1.9	10.2
Upriver	101,292	114,968	114,212	124,951	13.5	-0.7	9.4
Total Study Area	**413,059**	**515,507**	**522,939**	**582,119**	**24.8**	**1.4**	**11.3**
Washington	3,413,244	4,132,353	4,866,692	5,430,940	21.1	17.8	11.6
Oregon	2,091,533	2,633,156	2,842,337	3,140,585	25.9	7.9	10.5
Idaho	713,015	944,127	1,006,734	1,163,261	32.4	6.6	15.5
United States (000s)	203,302	226,542	248,710	261,658	11.4	9.8	5.2

Source: U.S. Census Bureau, 1970, 1980, 1990; State Estimated, 1995

Population in the Pacific Northwest and the nation as a whole continued to grow in the 1980s but at slower rates than in the preceding decade (Table 4.14-6). The study area experienced a relatively modest growth rate of 1.4 percent, with 11 of the 25 study area counties experiencing net-outmigration. Population in the downriver and reservoir subregions grew by 2.2 and 1.9 percent, respectively, while population in the upriver subregion decreased by 0.7 percent. The population of Benton County, which increased by 62 percent over the preceding decade, increased by 2.8 percent between 1980 and 1990.

From 1990 to 1995, population growth rates in Washington, Oregon, and Idaho ranged from two to three times the national average (Table 4.14-6). All but one of the study area counties reported population growth over this period, with Benton County accounting for approximately 35 percent of the net study area increase of 59,165. Population growth rates in the subregions ranged from 9.4 percent in the upriver subregion to 12.9 percent in the downriver subregion. Valley County, Idaho in the upriver subregion experienced the most significant growth rate in the study area with a population increase of 28.9 percent. Other study area counties with population growth rates exceeding 10 percent included Adams, Asotin, and Franklin counties in the reservoir subregion and Latah and Lewis counties in the upriver subregion.

4.14.1.4 Age

Average median age increased in all three subregions and all 25 study area counties between 1980 and 1990 (Table 4.14-7). Average median age in 1990 ranged from 33.2 years old in the reservoir subregion to 35.7 years old in the upriver subregion. Average median age in 1980 was around 30.5 years old in all three subregions in 1980. The median age is the middle age in each county. Half the population in the county is younger than this age, the other half is older. The average median ages presented by subregion in Table 4.14-7 are weighted averages of the median ages of the counties that make up each subregion. The upriver subregion counties saw the greatest increase in median age between 1980 and 1990, with increases ranging from 2 to 8.2 years. Median age in four of the nine upriver subregion counties increased by more than 5 years over this period.

Another measure of age is the dependency ratio. This ratio compares the population under 18 and over 64 years old with the population of working age. The average dependency ratio for each subregion is shown in Table 4.14-7. These ratios range from 72.3 in the upriver subregion to 74.5 in the downriver subregion. A dependency ratio of 70, for example, means that for every ten people of working age there are seven people under 18 or above 65 years of age.

Table 4.14-7. Age by Subregion, 1980-90

	1980	1990	Dependency Ratio, 1990
Downriver Average	30.7	34.8	74.5
Reservoir Average	30.5	33.2	74.3
Upriver Average	30.4	35.7	72.3

Source: U.S. Census Bureau, 1980, 1990

4.14.2 Communities

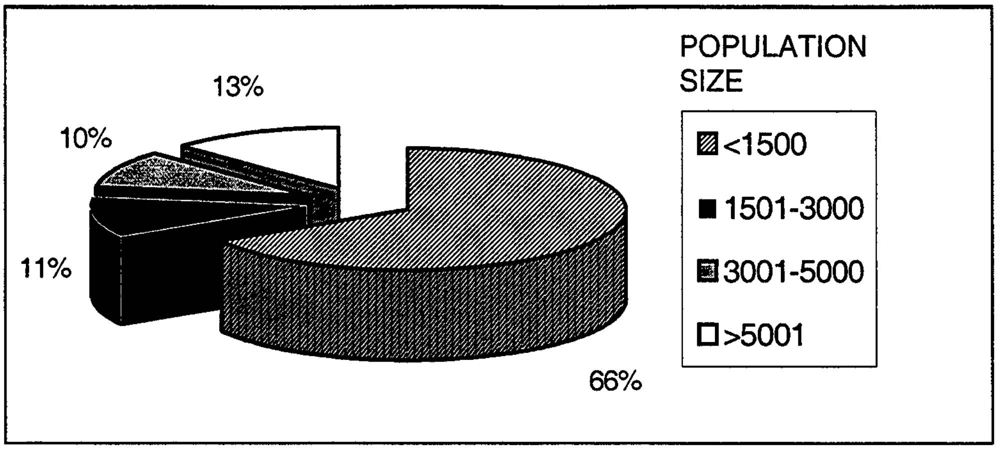
The following discussion, which focuses primarily on the communities located in the 25-county lower Snake River study area, draws on two primary source documents. These documents are the DREW social analysis report (DREW Social Analysis Workgroup, 1999) prepared for this FR/EIS and the Phase I community-based social impact assessment also developed as part of this study (Harris et al., 1999a). Summary information is also provided on nine focus communities located in southern Idaho some distance upriver from the four lower Snake River dams. This information is drawn from Phase II of the community-based social impact assessment (Harris et al., 1999b) prepared for this analysis.

4.14.2.1 Lower Snake River Study Area

The lower Snake River study area is, in general, sparsely populated and rural. Communities in the area do, however, range in size, economic activity, and their relationship to the lower Snake River.

Study area communities range from small rural towns with populations less than 200 to cities with populations from 8,000 to almost 50,000. The major population centers are the Tri-Cities (Richland, Kennewick, and Pasco), Walla Walla, the Quad-Cities (Pullman, Moscow, Lewiston, and Clarkston), and Hermiston/Pendleton. These larger cities serve as regional trade centers, educational centers, and provide a diversity of employment opportunities that range from manufacturing and professional services to tourism.

In general, the communities in the region are small with 66 percent having populations less than 1,500 and 60 percent having populations less than 1,000. Only five communities in the study region have populations greater than 20,000. The distribution of communities by size is shown in Figure 4.14-2. The majority of the 101 communities in the 25-county study area have increased in population since 1990. Communities located in rural areas that offer high quality scenery and recreational opportunities have tended to have particularly rapid growth rates.

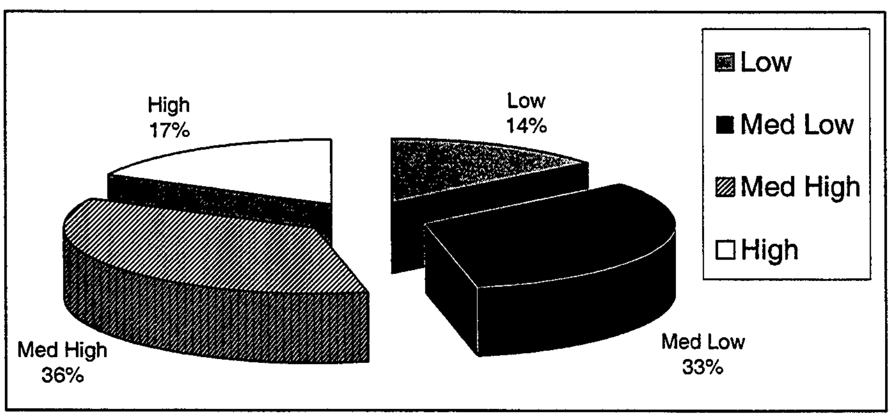


Source: DREW Social Analysis Workgroup, 1999

Figure 4.14-2. Distribution of Community Size in the Lower Snake Region

Economic Characteristics

The majority of towns in the region are small. Small towns typically have relatively narrow economic bases with fewer industries and fewer firms per industry than larger communities. Economic diversity may be measured based on the number of economic sectors present and the concentration of total direct employment in any one sector. The economic diversity index developed for the Interior Columbia Basin Ecosystem Management Project (ICBEMP) divided all the communities in the Interior Columbia particularly rapid growth rates. Basin into four categories of economic diversity - Low, Medium Low, Medium High, and High (Harris et al., 1999a). Based on the ICBEMP analysis, the majority of the communities in the lower Snake River study area fall in the Medium Low and Medium High categories (Figure 4.14-3).

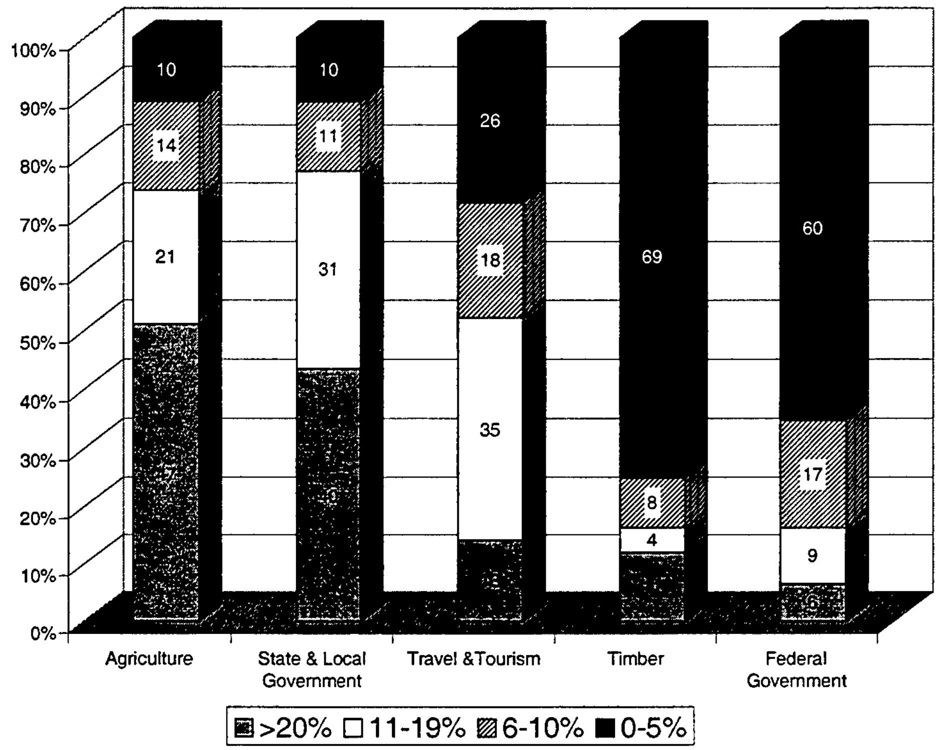


Source: DREW Social Analysis Workgroup, 1999

Figure 4.14-3. Percentage of Communities in LSR Region by Economic Diversity

Community resiliency, which may be defined as a town's ability to successfully deal with multiple social and economic changes, is a primary indicator of a community's health and vitality (USFS and BLM, 1997). Economic diversity is an important component of community resiliency. In the lower Snake River study area, communities in the lower categories of the economic diversity index are primarily small agricultural towns. The

distribution of communities by the percentage of employment in selected industrial sectors— agriculture, state, local and Federal government, timber, and travel and tourism—is displayed in Figure 4.14-4.



Note: Data obtained from the ICBEMP Study (USDA Forest Service and BLM, 1997) were only available for 92 of the 101 communities located in the lower Snake River study area.

Source: DREW Social Analysis Workgroup, 1999

Figure 4.14-4. Number of Lower Snake River Communities by Percentage of Direct Employment in Industrial Sectors

Almost half of the communities in the study area have 20 percent or more of their employment in agriculture, while 68 percent of the communities have 11 percent or more of their employment in this sector. This employment includes farm proprietors and employees, as well as farm services. State and local government, which includes school employees, is also an important employer at the community level. Over 40 percent of study area communities have 20 percent or more of total employment in this sector, while almost 80 percent have 11 percent or more. Travel and tourism, timber, and the Federal government sector also employ 20 percent or more of the labor force in selected communities.

While employment in the agricultural sector has declined in the Pacific Northwest and the lower Snake River study area over the past three decades, the data presented in Figure 4.14-4 indicate that agriculture is still a major employer in many communities. Similarly, while employment has declined in the forest products sector, this sector is still a major employer in a number of study area communities.

Selected Focus Communities

The DREW social analysis addresses social impacts at a regional scale and also provides information on potential impacts across a range of communities likely to be affected by the proposed alternatives. Nine focus communities were selected for detailed analysis. These focus communities are identified on Figure 4.14-1. The selected communities include those that would likely experience large potential impacts, positive or negative, under one or more of the alternatives. As a group, these communities are diverse in size, economic activity, and potential socioeconomic impacts. Tribal communities were not examined as part of this analysis. Tribal communities are discussed in Section 4.8, Native American Indians.

The community-based social impact assessment prepared for this FR/EIS examined the past and current situation of 18 potentially affected communities to gain a more detailed understanding of the potential future impacts of salmon restoration efforts. These 18 focus communities include the 9 communities examined as part of the social analysis. The community-based assessment process involved examining secondary data and conducting interactive forums in each of the communities. These forums, conducted by a team of social scientists from the UI, were designed to assess the perceptions of community residents of the past, present, and future situations in their communities and the likely impacts of various salmon restoration options. Communities were selected for this analysis based on a series of predetermined criteria including economic diversity and state of residence. The selected communities were also distributed across a second tier of classification variables that addressed transportation, population levels, and natural resource dependency.

The detailed community assessments involved a four-hour public forum in each of the 18 selected communities. These meetings allowed the UI team to record local perspectives on past community responses to economic and social change and assess potential social impacts that would result from the project. Each forum was open to all members of the affected community. In addition, active community members were targeted and asked to attend to ensure that a range of potential interests and perspectives were represented. The community forum process is described in more detail in Harris et al. (1999a).

Community Types

The UI team developed a community typology based on their initial theoretical sampling process and the results of the community forums. This typology identifies meaningful clusters of communities based on descriptive themes relevant to the proposed salmon recovery pathways and groups them based on land use patterns, economic composition, and connections to the lower Snake River. This typology provides a means of generalizing the results from the 18 community forums across a broader range of communities located within the study area.

The Community Typology developed by the UI team identified six Community Types: 1) Trade Center, 2) Highly Productive Dryland Agriculture, 3) Productive Dryland Agriculture, 4) Multiple Natural Resource Use, 5) Snake River Irrigated Agriculture, and 6) Columbia River Agriculture. Descriptions of these six community types are presented in Table 4.14-8.

Base case conditions are presented for the 18 focus communities in Table 4.14-9. The communities are grouped by community type.

Table 4.14-8. Community Type Descriptions

Community Type	Description
Trade Center	Trade center communities are typically characterized by diverse urban land use patterns with the dominant focus on intensely developed land types such as industrial, commercial, retail, residential, and parks and open spaces. These communities are characterized by a diverse economy that serves as a regional trade center. These communities directly use the Snake River for port facilities, transportation of commodities, fisheries, and tourism. Residents also use the river for personal recreation pursuits.
Highly Productive Dryland Agriculture	This type of community is characterized by less intensive, rural development with a predominance of agriculture-oriented industrial, commercial, and service establishments. A limited range of industrial sectors, often dominated by agriculture or state and local government, typically characterize the economy of this type of community. These communities are surrounded by highly productive, agricultural lands and directly use the Snake River for port facilities, and transportation of agricultural commodities. Residents also use the river for personal recreation pursuits.
Productive Dryland Agriculture	This type of community is similar to the Highly Productive Dryland Agriculture community type, with the exception of the surrounding agricultural lands, which tend to be productive and/or marginal rather than highly productive.
Multiple Natural Resource Use	These communities, characterized by natural and rural landscapes, are dominated by a mixture of resource-based uses such as tourism, forestry, fisheries, mining, farming, ranching, and conservation. These uses are evident throughout these communities in their industrial, commercial, retail, and service developments. A diverse range of industrial sectors, often including one or more resource-based industry (i.e., forestry, natural resource based tourism, and ranching), state and local government and/or Federal government, tends to characterize the economy of this type of community. These communities directly use the Snake River for port facilities and transportation of commodities, and indirectly use it for associated fisheries and tourism. Residents may also use the river for personal recreation pursuits.
Snake River Irrigated Agriculture	These communities are characterized by irrigated, rural landscapes. A limited range of industrial sectors, often dominated by agricultural activities or state and local government, typically characterize the economy of this type of community. These communities are influenced by highly developed, irrigated agriculture, such as orchards, vineyards, and row crops. They directly utilize the Snake River for port facilities, and transportation of agricultural commodities. Residents also use the river for personal recreation pursuits.
Columbia River Agriculture	This type of community is associated with the Columbia River and dominated by irrigated and/or dryland agriculture. Normally, these communities are characterized by less intense, rural development. A limited range of industrial sectors, often dominated by agriculture or state and local government, characterize the economy of this type of community. These communities do not directly utilize the Snake River for irrigation, transportation of commodities, or tourism. Residents may use the Snake River for personal recreation pursuits.

Table 4.14-9. Base Case Conditions for Selected Lower Snake River Study Area Focus Communities by Community Type

Typical Community Case	Population 1996-97	Subregion	Relation to Snake River	Economic Diversity	Dominant Industries
TRADE CENTER COMMUNITY TYPE					
Lewiston, ID	30,271	Reservoir	Port of Lewiston; Barging/Cruiselines/Transportation; Recreation	High	Travel & Tourism Forestry State/Local Government
Clarkston, WA	6,870	Reservoir	Port of Clarkston; Barging/Transportation; Recreation	High	Travel & Tourism State/Local Government
Kennewick, WA	49,090	Downriver	No direct economic relationship; Recreation	High	Travel & Tourism Diverse
Pasco, WA	25,300	Downriver	No direct economic relationship; Recreation	High	State/Local Government Travel & Tourism Agriculture
HIGHLY PRODUCTIVE DRYLAND AGRICULTURE COMMUNITY TYPE					
Colfax, WA	2,830	Reservoir	Barging of grain; Recreation	Medium	State/Local Government Agriculture
Genesee, ID	730	Upriver	Barging of grain; Recreation	Low	Agriculture State/Local Government
Pomeroy, WA	1,445	Reservoir	Barging of grain; Recreation	High	Agriculture Federal & State/Local Government
PRODUCTIVE DRYLAND AGRICULTURE COMMUNITY TYPE					
Kahlotus, WA	215	Downriver	Barging of grain; Employment; Recreation	Medium	Agriculture Federal & State/Local Government
Washtucna, WA	278	Reservoir	Barging of grain; Recreation	Low	Agriculture State/Local Government
MULTIPLE NATURAL RESOURCE USE COMMUNITY TYPE					
Enterprise, OR	2,035	Upriver	No direct economic relationship; Impacts on upriver fisheries	High	State/Local Government Agriculture Travel & Tourism
Orofino, ID	3,112	Upriver	No direct economic relationship; Impacts on upriver fisheries	High	State/Local Government Forestry Travel & Tourism
Riggins, ID	495	Upriver	No direct economic relationship; Impacts on upriver fisheries	Medium	Travel & Tourism Federal & State/Local Government Agriculture
Weippe, ID	566	Upriver	No direct economic relationship; Impacts on upriver fisheries	Low	Forestry State/Local Government Agriculture
SNAKE RIVER IRRIGATED AGRICULTURE COMMUNITY TYPE					
Prescott, WA	335	Reservoir	School district dependent for tax base on orchards irrigated from Snake River; Recreation	Medium	State/Local Government Agriculture
COLUMBIA RIVER AGRICULTURE COMMUNITY TYPE					
Adams, OR	265	Downriver	No direct economic relationship	Low	Agriculture
Burbank, WA	1,695	Reservoir	No direct economic relationship	Low	Federal & State/Local Government Agriculture
Stanfield, OR	1,770	Downriver	No direct economic relationship	Low	State/Local Government Agriculture Travel & Tourism
Umatilla, OR	3,375	Downriver	No direct economic relationship	Medium	Agriculture State/Local Government Travel & Tourism

Source: Harris et al., 1999a

4.14.2.2 Southern Idaho

In response to concerns raised about potential impacts to communities located upriver of the lower Snake River study area, the UI team conducted nine community forums in communities located in southern Idaho. The focus community selection process and the forums were largely the same as those employed in the lower Snake River study area. The nine communities were grouped based on the initial theoretical sampling process and the results of the community forums. Three community types were identified: the trade center community type (Boise and Twin Falls), the multiple natural resource use community type (Ashton, Cascade, and Salmon), and the middle Snake River irrigated agricultural community type (Firth, Hagerman, Homedale, and Rupert). Base case conditions are presented for the nine focus communities in Table 4.14-10. The communities are grouped by community type.

Table 4.14-10. Base Case Conditions for Selected Southern Idaho Focus Communities by Community Type

Typical Community Case	Population 1996-97	Subregion	Relation to Snake River	Economic Diversity	Dominant Industries
TRADE CENTER COMMUNITY TYPE					
Boise, ID	166,647	Upper Basin	Transportation, Flow Augmentation	High	Government; Retail; Tourism
Twin Falls, ID	31,989	Upper Basin	Transportation, Flow Augmentation	High	Government; Retail; Tourism
MULTIPLE NATURAL RESOURCE USE COMMUNITY TYPE					
Ashton, ID	1,085	Upper Basin	Transportation, Flow Augmentation	High	Agriculture; Timber; Services
Cascade, ID	1,059	Upper Basin	Flow Augmentation	Medium	Government; Tourism, Timber
Salmon, ID	3,270	Upper Basin	Transportation, Flow Augmentation, Upriver Fisheries	High	Agriculture; Government; Tourism
MIDDLE SNAKE RIVER IRRIGATED AGRICULTURE COMMUNITY TYPE					
Firth, ID	453	Upper Basin	Transportation, Flow Augmentation	Low	Food processing; Agriculture
Hagerman, ID	812	Upper Basin	Transportation, Flow Augmentation	Medium	Agriculture; Government
Homedale, ID	2,285	Upper Basin	Transportation, Flow Augmentation	High	Agriculture/ranching; Mining; Government
Rupert, ID	5,936	Upper Basin	Transportation, Flow Augmentation	Medium	Food processing; Agriculture; Fed/state government

Source: Harris et al., 1999b

4.14.3 Low Income and Minority Populations

4.14.3.1 Poverty

The percentage of the population below the poverty rate increased in all three subregions between 1979 and 1989 (Table 4.14-11). The percent of the reservoir subregion population below the poverty rates was particularly notable and well above the average for Washington State and the nation as a whole. Reservoir subregion counties with about 20 percent of their population below the poverty rate include Franklin, Asotin, and Columbia counties, all located in Washington State.

The share of population below the poverty rate in the downriver and upriver subregions in 1989 was 13.4 and 14.9 percent, respectively. Counties with relatively high portions of their population below the poverty rate in 1989 included Umatilla, Oregon in the downriver subregion (16.5 percent), and Latah and Lemhi counties, both in Idaho and the upriver subregion, with poverty rates of 18.5 and 20.2 percent, respectively.

Table 4.14-11. Poverty Rates, 1979 and 1989

	1979 (%)	1989 (%)
Downriver Average	9.0	13.4
Reservoir Average	14.3	20.1
Upriver Average	13.0	14.9
Washington	9.8	10.9
Oregon	10.7	12.4
Idaho	12.6	13.3
United States	12.4	13.1

Source: U.S. Census Bureau, 1980, 1990

4.14.3.2 Race

The 25-county study area in 1990 contained a larger proportion of Caucasians (90.3 percent) and American Indians (1.7 percent) than the United States (80 percent and 0.8 percent, respectively), a smaller proportion of African Americans (0.9 percent compared to 12 percent nationally), and a similar proportion of people of Hispanic origin (8.3 percent compared to 9 percent nationally). Hispanics are the largest non-Anglo group in the study area, increasing by 20,554 or 90.2 percent between 1980 and 1990 (Table 4.14-12). Although the fastest growing ethnic group in the state, Hispanics accounted for just 6.1 percent of Washington's population in 1996. The Caucasian population experienced an absolute decline of 12,251 or 2.5 percent over this period.

Table 4.14-12. Race and Ethnicity in the 25 Study Counties 1980 to 1990

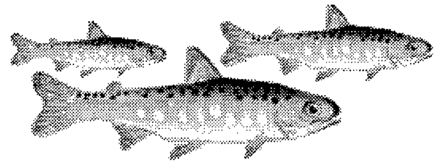
	1980		1990		1980-1990	
	Total	% of Total	Total	% of Total	Total	% Change by Group
Total Population	515,507	100.0	522,999	100.0	7,492	1.5
Caucasian	484,779	94.0	472,528	90.3	-12,251	-2.5
African American	4,074	0.8	4,493	0.9	419	10.3
Indian	6,932	1.3	8,698	1.7	1,766	25.5
Asian	4,767	0.9	8,434	1.6	3,667	76.9
Other Race	14,953	2.9	28,889	5.5	13,936	93.2
Hispanic Origin	22,783	4.4	43,337	8.3	20,554	90.2

Note: Census data are subject to self-reporting and processing errors. This is particularly the case with Native Americans and Hispanic seasonal workers. The Census Bureau considers "Hispanic Origin" to be an ethnic category rather than a racial category. People of Hispanic origin may be of any race and are counted in the race figures as well. People categorized in the "Other Race" category include those who write in other racial categories, such as multiracial or multiethnic, on the census form.
Source: U.S. Department of Commerce, Bureau of the Census

Relatively large concentrations of minority groups were present in two of the seven reservoir counties in 1990. Over 30 percent of the populations in Adams and Franklin counties, Washington, were persons of Hispanic origin. Hood River County, Oregon, located in the downriver subregion also had relatively large Hispanic population of 16.3 percent. Franklin County's African American population was also relatively high,

3.5 percent compared to a study area average of 0.9 percent. This is still substantially below the national average of 12 percent.

Relatively large concentrations of Indians were evident in three downriver and one upriver counties in 1990, with Indian populations ranging from 3.1 to 4.8 percent compared to the study area average of 1.7 percent. These counties each coincide with the location of an Indian Reservation. Individual Tribe descriptions are provided in Section 4.8, Native American Indians. The discussion in that section includes a baseline description of the 14 tribes within the study area. It also addresses circumstances in the Shoshone-Bannock's Hall and Duck Valley reservations located in southern Idaho. (See Technical Appendix I, Economics, and the Tribal Circumstances and Perspectives report for further information.)



4.15 Aesthetics

The aesthetics study area encompasses the 140-mile river canyon along the lower Snake River. This section presents a description of the study area, aesthetic conditions, views, and viewers.

4.15.1 Landscape Character

The lower Snake River passes through the Blue Mountains and Columbia basalt plain of Oregon and Washington. The landscape in the western, downstream end of the subregion is characterized by low hills covered with steppe vegetation. Due to the slight twisting nature of the river valley, views within the valley rarely extend beyond 2 to 3 miles. Reservoir pool width along the 140-mile corridor generally varies between 1 and 1.25 miles.

Land uses near and adjacent to reservoirs include agriculture, port facilities, recreation, and residential. Development near the reservoirs is fairly intensive at the eastern and western ends (Lewiston-Clarkston and the Tri-Cities, respectively). Parks, marinas, and housing developments adjacent to the river create a suburban/urban character in places. By contrast, the remote interior portions of the river corridor are less developed and relatively difficult to access (BPA et al., 1995).

4.15.2 Project Aesthetic Conditions

Aesthetically pleasing views are a critical component of most outdoor recreation activities. Visual quality within the study area is directly affected by varying the river and reservoir levels. Currently, the aesthetic appearance of the reservoirs in the system is directly related to pool elevation. In general, a lake will appear more aesthetically appealing when it is at or near full pool than when it is drawn down. The run-of-river reservoirs on the lower Snake River only experience 3 to 5 feet daily fluctuations and visual quality does not change much throughout the year.

Water quality parameters that have an aesthetic impact include water temperature, odor, color, turbidity, oil and grease slicks, foam, litter and other debris, algae, aquatic weeds, and dead fish. The general appearance of a water body is an important factor in its acceptance for recreation use and these parameters are closely related to recreation

demand. One of the most important water quality variables is temperature. Excessively warm or cold water temperature has an adverse effect on the enjoyment of swimming and may be unhealthy. Perhaps more importantly, high or low water temperatures often create biological conditions unsuitable for recreation or game fish habitat. Warm water temperatures in combination with nutrients can stimulate growths of aquatic weeds and algae but these effects are not known to limit recreation along the lower Snake River.

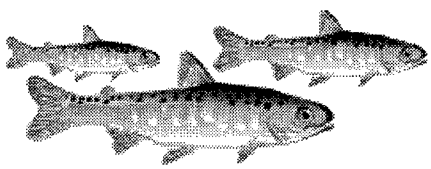
The color and clarity of water along the lower Snake River is not ideal, but it is not a known problem or limiting factor for recreation.

4.15.3 Views and Viewers

Typical scenery along the lower Snake River includes rocky shorelines with intermittent sand beaches and irrigated parks. Above rough high rock cliffs, agricultural land predominates on often rolling hills. With two exceptions, the lower Snake River facilities are not visible for any great length of time from major roads or highways. Wawawai River Road (a country road) and State Route 193 follow the north side of Lower Granite Reservoir. U.S. 12 follows the south side of Lower Granite Reservoir for approximately 7 miles from Clarkston to Silcott. Near Pasco, U.S. 12 crosses the river and offers views of the lower Snake River near its confluence with the Columbia River. The river is crossed at six locations, including at all four dams, by state or county highways.

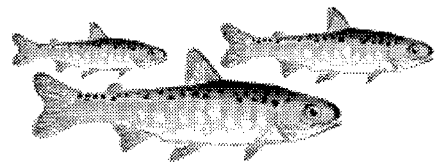
People viewing the study area generally fall into two categories: 1) local residents and those who work along the river in agriculture, transportation, and fisheries; and 2) recreationists using the reservoirs or the river. Most local residents live in the Lewiston-Clarkston area. Tri-Cities residents and travelers often view the dams and reservoirs from U.S. 12 and other nearby roads. Details on recreation and tourism, including annual visitation rates for lower Snake River recreation sites and the projects themselves, are provided in Section 4.12, Recreation and Tourism.

Most viewers of the study area are recreationists using the reservoirs or rivers: local residents, primarily of Lewiston-Clarkston and the Tri-Cities, and travelers on U.S. 12 at either end of the lower Snake reach (BPA et al., 1995).



Chapter 5

Environmental Effects of Alternatives



5.1 Geology and Soils

This section addresses the environmental effects of the alternatives on geologic and soil resources in the project area. See Table 5.1-1 for a summary of potential effects.

Table 5.1-1. Summary of Potential Effects of the Alternatives on Geology and Soils

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Geology and Soils	Continued current rate of natural hillslope erosion and wave-induced erosion. No expected effects to soils.	Same as Alternative 1.	Same as Alternative 1.	• Approximately 14,000 acres of inundated land would be exposed, including mudflats and oversteepened banks that could slough and erode during peak flows. • Roadway and railroad embankments could fail. • Increased total suspended solid concentrations until new flow regime stabilizes.

5.1.1 Alternative 1—Existing Conditions

Under Alternative 1—Existing Conditions, natural hillslope erosion and wave-induced erosion on the reservoir banks would continue at the existing rates. There would be no adverse effects to soil resources.

5.1.2 Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 3—Major System Improvements

The effects under Alternatives 2 and 3 would be essentially the same as under Alternative 1—Existing Conditions because current project operations would continue.

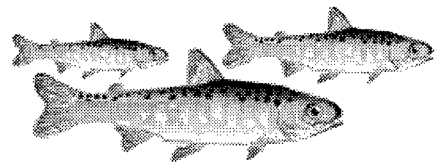
5.1.3 Alternative 4—Dam Breaching

The breaching of dams would lower the levels of the reservoirs such that a free-flowing river would occur. Approximately 14,000 acres of inundated land would be exposed as a result of the dam breaching in the lower Snake River Reach (Table 5.1-2). The lowering of the current water levels by breaching the dams would expose mudflats and oversteepened banks that are susceptible to sloughing and erosion during peak flow events. In addition, as drawdown occurs, areas of the roadway and railroad embankments along the river are anticipated to fail due to steep slopes, saturated soils, and pore pressure increase. During the 1992 drawdown tests in Lower Granite Reservoir, water levels were lowered 33 feet, exposing substantial mudflats along the shoreline of the reservoir. Slope failures observed during the 1992 drawdown occurred along the contact between the structure fill and the natural foundation material. It was estimated that dam breaching could result in 68 potential failure areas on the 140-mile lower Snake River Reach. It is anticipated that there could be at least two large failures on both the Little Goose and Lower Granite reservoirs, and one large failure on both Ice Harbor and Lower Monumental reservoirs (see Technical Appendix D, Natural River Drawdown Engineering).

Table 5.1-2. Acres of Exposed Shoreline Following Alternative 4—Dam Breaching

Reservoir	Area of Current Reservoir (acres)	Acres of Shoreline Exposed)
Ice Harbor (Lake Sacajawea)	9,002	3,880
Lower Monumental (Lake Herbert G. West)	4,960	1,443
Little Goose (Lake Bryan)	10,825	5,640
Lower Granite (Lower Granite Lake)	8,448	2,808

Total suspended solids (TSS) concentrations could be reasonably expected to be much higher during the proposed drawdown conditions until the new channel bed and banks stabilize and equilibrate with the flow regime (see Section 5.3, Water Resources). In addition, the sediment accumulated on the banks of the reservoir and at the deltas of the streams that discharge into the river would become exposed to soil and rain.



5.2 Air Quality

The analysis of air quality impacts associated with the four Lower Snake River Juvenile Salmon Migration Feasibility Study alternatives addresses four potential impact issues. These issues are: 1) fugitive dust emissions resulting from potential dam breaching activities (i.e., removal of the earthen portion of the dams and other site work); 2) the change in the quantity and distribution of vehicle emissions as commodities are shifted from barges to trains and trucks; 3) fugitive dust emissions resulting from dry exposed lake sediments during high wind events; and 4) atmospheric emissions associated with replacement power generation by thermal power plants.

This section identifies the short-term and long-term effects on air quality of each of the four alternatives in terms of these issues. Table 5.2-1 summarizes these potential effects. Short-term effects are associated with construction- and deconstruction-related activities and newly exposed sediments that are prone to wind erosion. Long-term effects are those that persist after systems have stabilized (e.g., revegetation of exposed sediments, replacement of lost power generation and barge transportation). This section also discusses mitigation measures and cumulative effects. Information provided in this section is described in greater detail in Technical Appendix P, Air Quality.

Table 5.2-1. Summary of Potential Effects of the Alternatives on Air Quality

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Construction-related fugitive emissions	No change from current conditions.	Same as Alternative 1.	Slight increase in emissions from particulate matter associated with mixer trucks and haul roads used for SBC and other modifications.	Excavation fugitive emissions (PM_{10}) from removal of the core material and from material handling activities.
Emissions associated with loss of barge transportation	No change from current conditions.	Slight increase in emissions from increased barging of juvenile salmon.	Same as Alternative 1.	Increase in some emissions (criteria air pollutants) from the loss of barge transportation.
Fugitive dust from exposed sediments	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	Increase in fugitive dust from exposed reservoir sediments; some mitigation from revegetation.
Emissions associated with replacement power generation	Slight increase in emissions from new power plants that may be built as power demand increases.	Same as Alternative 1.	Same as Alternative 1.	Increase in emissions from replacement power generation (criteria, HAPs, and GHGs).

5.2.1 Study Methods

The study methods used to analyze potential air quality impacts associated with the four alternatives are identified below by issue. Most of the discussion in this section is focused on Alternative 4—Dam Breaching because little or no change in air quality would be expected under the first three alternatives. Additional information on these study methods is provided in Technical Appendix P, Air Quality.

5.2.1.1 Construction-related Fugitive Emissions

In terms of atmospheric emissions, breaching of the lower Snake River dams would be equivalent to a large construction project. U.S. Environmental Protection Agency (EPA) construction-related emission factors were used to estimate fugitive dust emissions related to breaching of the lower Snake River dams (EPA, 1998a). Technical Appendix D, Natural River Drawdown Engineering, provides conceptual designs for breaching the four lower Snake River dams, creating river channelization, and modifying the reservoir. This analysis assumes that all four facilities would be demolished in 2 years, but deconstruction would most likely last a number of years. Many of the deconstruction details were approximated; therefore, only a preliminary analysis of fugitive emissions is presented. Deconstruction emissions estimates for Alternative 4—Dam Breaching do not include emissions associated with reservoir modifications. Construction details sufficient for emission estimates of reservoir modifications have not been specified. Details of structural enhancements to improve downstream migration of

juvenile salmon (e.g., surface bypass and collection systems) are provided in Technical Appendix E, Existing Systems and Major Systems Improvements Engineering.

5.2.1.2 Emissions Associated with Loss of Barge Transportation

Air emissions resulting from loss of barge traffic were estimated using the number of river, train, and road miles that would be required to transport commodities affected by Alternative 4—Dam Breaching. The transportation-related emissions estimates do not consider tire and brake emissions. Two sources provided data for this analysis. First, the Eastern Washington Intermodal Transportation Study (EWITS) (Lee and Casavant, 1998) conducted a 6-year study funded jointly by the Federal government and the Washington State Department of Transportation that included an examination of transportation-related energy consumption and air emissions associated with breaching of the four lower Snake River dams. The study looked at wheat and barley transportation-related emissions and extrapolated that data to other commodities. Second, the Transportation and Navigation Study (Corps, 1999d) provided the number of train and truck bushel-miles needed to transport the wheat and barley harvest following dam breaching. This data was also extrapolated to other commodities. Transportation-related emissions estimated from the EWITS and Transportation and Navigation Study data produced different values. Because both studies included uncertainty, the emission estimates presented in this section are an average of the emissions provided in the two studies.

5.2.1.3 Fugitive Dust from Exposed Sediments

Windblown fugitive dust emissions were estimated using an EPA method of predicting the amount of particulate matter with aerodynamic diameters less than 10 micrometers (PM_{10}) emitted during a wind erosion event (EPA, 1998a). The analysis used 1984 through 1991 wind data from Pendleton, Oregon; Spokane, Washington; and Yakima, Washington. Information from related particulate studies at Lake Koocanusa in Montana and Owens Lake in California is also used to supplement results.

5.2.1.4 Replacement of Power Generation

Changes in Pacific Northwest hydropower generation could affect the amount of energy bought and sold, and the number of new generating facilities built throughout an interconnected power system that includes all or part of 14 western states, two Canadian provinces, and a small area of northern Mexico. This area is managed by the Western Systems Coordinating Council (WSCC). This air quality analysis attempts to estimate how air emissions would change in the WSCC-managed region because of the loss of hydropower generated by the four lower Snake River facilities. The analysis is based on the findings of the Technical Report on Hydropower Cost and Benefits that was developed by the Drawdown Regional Economic Workgroup Hydropower Impact Team (DREW HIT, 1999). This report considered existing coal-fired, fuel-oil-fired, and natural gas-fired generating units in the WSCC-managed area. It assumed that new generating units would be natural gas-fired combined cycle units. A power systems model (PROSYM) was used to predict carbon dioxide (CO_2), nitrogen dioxide (NO_x), and sulfur dioxide (SO_2) emissions for new and existing units. These estimates were

extrapolated to carbon monoxide (CO), volatile organic compounds (VOCs), PM_{10} and other pollutants using published emission factors.

5.2.2 Impacts of the Alternatives

5.2.2.1 Alternative 1—Existing Conditions

Under Alternative 1—Existing Conditions, the Snake River facilities would remain in place and barge traffic would continue on the Snake River waterway. No changes from currently planned operations and improvements are planned under this alternative. Emissions estimates presented in this alternative represent existing conditions, or emissions representative of a baseline year.

Construction-related Fugitive Emissions

Other than operation and maintenance and other planned improvements, no new construction and deconstruction activities would take place under Alternative 1—Existing Conditions. Therefore, no new construction- or deconstruction-related atmospheric emissions would result from this alternative.

Emissions Associated with Loss of Barge Transportation

Barge transportation on the navigable portions of the Columbia and Snake rivers would continue with Alternative 1—Existing Conditions. Although there would not be any air quality impacts, transportation-related emissions estimates for this alternative were used to predict the changes associated with Alternative 4—Dam Breaching.

Fugitive Dust from Exposed Sediments

Under Alternative 1—Existing Conditions, the four lower Snake River reservoirs would not be drained. Therefore, there would be no fugitive emissions from exposed reservoir sediments.

Emissions Associated with Replacement Power Generation

Power generation by the four lower Snake River hydropower facilities would continue under Alternative 1—Existing Conditions, eliminating the need for replacement power. However, the demand for energy would likely continue to grow, resulting in a possible need for additional generating capacity. Emissions from generating units throughout the WSCC-managed area for 2010, representative of Alternative 1—Existing Conditions, are presented in Table 5.2-2. These figures include emissions that would be generated by new natural gas-fired combined cycle units that would go online by 2010, regardless of the continued operation or removal of the four lower Snake River hydropower facilities.

Summary of Effects for Alternative 1—Existing Conditions

No emission increases are estimated for Alternative 1—Existing Conditions. Therefore, this alternative would have no short-term or long-term air quality effects. Under this alternative, Snake River barge traffic would continue, and new power plants would likely continue to be built as power demand increases. Emissions from these new plants have been factored into the analysis.

Table 5.2-2. Power Generating Emissions for the Year 2010 (tons per year)

Generation Resource	CO	CO_2	NO_x	PM_{10}	SO_2	VOC	Benzene	Formaldehyde
Alternative 1—Existing Conditions								
Coal	248,938	255,839	50,515	48,580	451,918	740	4	1
Fuel Oil	343	1,179	45	4	493	1	0	0
Natural Gas	154,343	157,214	7,197	683	4,972	391	0	44
Total Emissions	***403,624***	***414,233***	***57,757***	***49,267***	***457,383***	***1,132***	***4***	***45***
Alternative 4—Dam Breaching								
Coal	249,897	256,825	50,612	48,769	454,000	742	4	1
Fuel Oil	410	1,258	46	4	500	1	0	0
Natural Gas	157,451	160,336	7,273	690	4,696	391	0	44
Total Emissions	***407,758***	***418,420***	***57,931***	***49,463***	***459,196***	***1,134***	***4***	***45***
Change in Power Generating Emissions (Dam Breaching Emissions Minus Existing Conditions Emissions)								
Coal	959	985	97	189	2,082	2	0	0
Fuel Oil	67	78	1	0	7	0	0	0
Natural Gas	3,108	3,122	76	7	(276)	0	0	0
Total Emissions	***4,134***	***4,186***	***174***	***196***	***1,813***	***2***	***0***	***0***
Percent Increase	1.0	1.0	0.3	0.4	0.4	0.2	0.0	0.0

Source: DREW HIT, 1999

5.2.2.2 Alternative 2—Maximum Transport of Juvenile Salmon

Under Alternative 2—Maximum Transport of Juvenile Salmon, juvenile fishway systems would be operated to maximize fish transport. This would result in an increased number of fish being transported downstream by trucks or barges.

Construction-related Fugitive Emissions

Construction and deconstruction activities would not take place under this alternative. Therefore, no construction- or deconstruction-related atmospheric emissions would result from this alternative.

Emissions Associated with Barge Transportation

Barge transportation on the navigable portions of the Columbia and Snake rivers would continue with this alternative. Transportation-related air emissions would likely be slightly higher than the emission estimates presented in Alternative 1—Existing Conditions due to the increased number of trips by trucks and barges needed to achieve maximum transport of juvenile salmon.

Fugitive Dust from Exposed Sediments

Under this alternative, the four lower Snake River reservoirs would remain in their current condition. There would be no fugitive emissions from exposed reservoir sediments.

Emissions Associated with Replacement Power Generation

Power generation by the four lower Snake River hydropower facilities would continue, eliminating the need for replacement power and associated air emissions. Power

generation emissions associated with this alternative are projected to be identical to the emissions predicted for Alternative 1—Existing Conditions.

Summary of Effects for Alternative 2—Maximum Transport of Juvenile Salmon

Transportation-related air emissions for this alternative would be slightly higher than emissions under Alternative 1—Existing Conditions due to the increased number of trips made by trucks and barges to achieve maximum transport of juvenile salmon. Only minor long-term air quality effects would result. As with Alternative 1—Existing Conditions, Snake River barge traffic would continue, and new power plants would likely continue to be built as power demand increases. Emission estimates for these new plants are identical to those included in Alternative 1—Existing Conditions.

5.2.2.3 Alternative 3—Major System Improvements

Structural enhancements to improve downstream migration of juvenile salmon would be added to each of the four lower Snake River hydropower facilities under this alternative. The proposed enhancements consist of various surface bypass collection (SBC) system. Details and designs for Alternative 3—Major System Improvements are provided in Technical Appendix E, Existing Systems and Major Systems Improvements Engineering.

Construction-related Fugitive Emissions

System enhancements would consist of SBC systems combined with structural modifications at each project. The SBC structures, consisting mostly of channels, could be built from components constructed offsite, or could be built in-place. Therefore, construction-related air emissions for this alternative would be very small and would include particulate matter emissions from mixer trucks and haul roads. For comparison of alternatives, this analysis conservatively assumed a total of one ton of PM_{10} emissions for structural enhancement at all four facilities. Furthermore, it was assumed that construction would take place in one year.

Emissions Associated with Barge Transportation

Barge transportation on the navigable portions of the Columbia and Snake rivers would continue under this alternative. Transportation-related air emissions would be identical to the emission estimates presented in Alternative 1—Existing Conditions.

Fugitive Dust from Exposed Sediments

For this alternative, the four lower Snake River reservoirs would remain in their current condition. There would be no fugitive emissions from exposed reservoir sediments.

Emissions Associated with Replacement Power Generation

Power generation by the four lower Snake River dams would continue, eliminating the need for replacement power and associated air emissions. Power generation emissions associated with this alternative are projected to be identical to those predicted for Alternative 1—Existing Conditions.

Summary of Effects for Alternative 3—Major System Improvements

Minor construction-related emission increases are anticipated for this alternative. Therefore, only minor short-term air quality effects would result. As with Alternative 1—Existing Conditions, Snake River barge traffic would continue, and new power plants would likely continue to be built as power demand increases. Emission estimates for these new plants are identical to those of Alternative 1—Existing Conditions.

5.2.2.4 Alternative 4—Dam Breaching

Air quality issues associated with Alternative 4—Dam Breaching include impacts from demolition-related emissions, loss of barge transportation, windblown fugitive dust from exposed dry sediments, and emissions from thermal power plants used to replace hydropower.

Construction-related Fugitive Emissions

The steps required to breach each of the four lower Snake River dams include lowering the reservoir, excavating embankments, removing cofferdams, routing the river around concrete structures, and constructing levees as necessary. Removing the core material of the dams and constructing levees would produce fugitive dust emissions. PM_{10} emission sources include material handling activities such as hauling, dumping, bulldozing, and grading. Table 5.2-3 presents estimated PM_{10} emissions by hydropower facility and construction activity. Total PM_{10} emissions for the four facilities would be 305 tons per year (TPY). With a 2-year breaching schedule, the emissions would be spread out over the full 2-year period.

Table 5.2-3. Estimated Demolition-Related PM_{10} Emissions (TPY)

Operation	Ice Harbor	Lower Monumental	Little Goose	Lower Granite
Bulldozing	3.5	2.6	2.6	3.1
Hauling	7.7	28.3	47.6	54.9
Dumping	0.5	0.2	0.3	0.3
Grading	46.5	34.3	31.5	41.0
Total	**58.2**	**65.4**	**82.0**	**99.3**

Source: Technical Appendix P, Air Quality

Breaching of the dams would incorporate standard construction practices to suppress fugitive dust, such as spraying haul roads with water. Some of the dam core material would be saturated with water to reduce the potential for fugitive dust emissions.

Emissions Associated with Loss of Barge Transportation

Barge transportation on the navigable portions of the Snake River would cease under Alternative 4—Dam Breaching. Grain quantities normally trucked to river ports on the Snake River would be trucked to elevators located on rail lines, or to river ports at or below the Tri-Cities area for barge shipment. According to EWITS, elevator to river port shipments would decrease 21 percent, while elevator to Portland rail shipments would

increase by the same amount. About 28 million bushels of wheat would switch from barges to trains. About 62 percent of the barley harvest is trucked to non-Snake River ports and then barged to Portland. The volume of barley barged to Portland would decrease only slightly without barging on the lower Snake River. Additional transportation information is provided in Sections 4.9 and 5.8 (Transportation).

Under Alternative 4—Dam Breaching, the EWITS data suggest that NO_x, PM_{10}, and VOC emissions would increase; CO emissions would remain about the same; and SO_2 emissions would decrease. The Transportation and Navigation Study data indicates that CO, NO_x, PM_{10}, and VOC emissions would increase and SO_2 emissions would stay about the same. The averages of the two total emissions estimates are presented in Table 5.2-4.

Table 5.2-4. Transportation-Related Emissions[1/] (TPY)

Alternative	CO	VOC	NO_x	PM_{10}	SO_2
Alternative 1 – Existing Conditions	218	280	1,586	49	245
Alternative 4 – Dam Breaching	203	370	1,566	58	174

[1/] Emissions estimates are an average of the estimates from the EWITS and Transportation and Navigation Study Data.

Sources: Corps, 1999d; Lee and Casavant, 1998

Fugitive Dust from Exposed Sediments

During and after dam breaching construction activities, exposed reservoir sediments would dry and become subject to wind erosion. Because large areas of dry sediments would be exposed, total PM_{10} emissions could be large. The estimated annual average PM_{10} emissions under Alternative 4—Dam Breaching for the four reservoirs, based on data from Pendleton, Oregon; Spokane, Washington; and Yakima, Washington are presented in Table 5.2-5. Residences along the river would be most susceptible to windblown dust from exposed sediments. Because the Snake River valley would channel the winds, residences located where the river bends would be most susceptible to windblown dust.

Table 5.2-5. Annual Average PM_{10} Emissions by Reservoir under Alternative 4—Dam Breaching (TPY)

Reservoir	PM_{10} Emissions
Ice Harbor	1,555
Lower Monumental	1,224
Little Goose	1,861
Lower Granite	1,652
Total	**6,292**

Source: Technical Appendix P, Air Quality

The Revegetation Plan in Technical Appendix D, Natural River Drawdown Engineering calls for seeding the exposed bottom sediments as the water recedes, and restricting access to the dry reservoirs, thereby minimizing the amount of available erodible material. This analysis assumes that mitigation efforts would reduce emissions by only 50 percent. Rain often accompanies strong winds. This analysis did not screen out

occasions of precipitation with strong winds, but it did reduce the annual emission estimates to account for the number of days of precipitation.

Emissions Associated with Replacement Power Generation

Hydropower generation does not result in air pollutant emissions. The loss of generation from the four lower Snake River hydropower facilities would require replacement of power-generating capacity, which could result in an increase of criteria air pollutants, toxic air pollutants (TAPs), and greenhouse gases (GHGs). The Technical Report on Hydropower Costs and Benefits (DREW HIT, 1999) concluded that it would not be necessary to replace all 3,500 megawatts (MW) of the four lower Snake River facilities' capacity.

The PROSYM model was used to predict air emissions under Alternative 4—Dam Breaching for 2010. The analysis considered all generating units in the WCSS-managed area, new natural gas-fired combined cycle units that would be constructed regardless of the fate of the four lower Snake River facilities, and 890 MW of replacement power that would be constructed in the Pacific Northwest. Predicted emissions by fuel type and generating source are provided in Table 5.2-2 and Technical Appendix P, Air Quality.

CO and CO_2 emissions are predicted to increase by 4,489 and 4,636,511 TPY, respectively. About 65 percent of this increase would be from the new combined cycle plants. SO_2 emissions are predicted to increase by 2,204 TPY, mostly as a result of an increase in Pacific Northwest coal plants. NO_x, PM_{10}, VOCs, benzene, and formaldehyde are predicted to increase because of Pacific Northwest coal and natural gas combustion. Emissions from the combustion of Alberta, Arizona, and New Mexico coal and emissions from some of the California Independent Power Producers (IPPs) are predicted to decrease.

The analysis indicates that total emissions throughout the WCSS-managed region would increase from about 0.39 to 1.1 percent, depending on the individual pollutant. Percentage increases in emissions above existing conditions are presented in Table 5.2-2.

Summary of Effects for Alternative 4—Dam Breaching

Alternative 4—Dam Breaching would result in demolition fugitive emissions (PM_{10}), emissions associated with the loss of barge transportation (criteria air pollutants), fugitive dust from exposed reservoir sediments, and emissions associated with replacement power generation (criteria and hazardous air pollutants, and GHGs).

5.2.3 Cumulative Effects

Emission increases above those estimated for Alternative 1—Existing Conditions are presented in Table 5.2-6. Emissions under Alternatives 2 and 3 would be essentially the same as those estimated for Alternative 1—Existing Conditions.

Transportation-related air emissions would be slightly higher under Alternative 2—Maximum Transport of Juvenile Salmon due to the increased number of trips made by trucks and barges to maximize juvenile salmon transportation. Minor construction-related emissions are anticipated under Alternative 3—Major System Improvements.

No cumulative effects are anticipated under the first three alternatives. The magnitude of the cumulative effects under Alternative 4—Dam Breaching would depend on the dam breaching schedule. Maximum emissions would occur if all four dams were removed at once, as was assumed for the emission estimates. In this scenario, the deconstruction and fugitive windblown emissions would occur in the same year. The increase in transportation and power generation emissions would take place as the commerce and power systems adjust to the loss of the lower Snake River hydropower facilities and as new thermal power plants come on line.

Emissions associated with increases in truck and rail transportation would be distributed in five states (Idaho, Montana, Washington, Oregon, and North Dakota). Most of the emission increases would be in southeastern Washington.

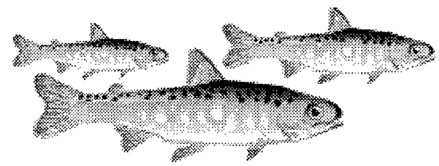
Emissions associated with replacement power would be distributed over the entire WCSS-managed area, covering the western United States.

Unavoidable adverse effects under the first three alternatives are limited to emissions from new power plants required to meet anticipated growth in demand. The different types of air emissions associated with Alternative 4—Dam Breaching are all unavoidable if this alternative is selected.

Table 5.2-6. Summary of Emissions (TPY)

	CO	CO_2	NO_x	PM_{10}	SO_2	VOC	Benzene	Formaldehyde
Alternative 1—Existing Conditions								
Demolition								
Transportation	218		1,586	49	245	280		
Windblown Dust								
Power Generation	403,624	414,233,886	57,757	49,267	457,383	1,132	4	45
Total	***403,842***	***414,233,886***	***59,343***	***49,317***	***457,628***	***1,411***	***4***	***45***
Alternative 4—Dam Breaching								
Demolition				304				
Transportation	203		,566	58	17	370		
Windblown Dust				6,292				
Power Generation	407,758	418,420,690	57,931	49,463	459,19	1,134	4	45
Total	***407,961***	***418,420,690***	***59,497***	***56,118***	***459,76***	***1,505***	***4***	***45***
Change	**4,119**	**4,186,804**	**154**	**6,801**	**1,74**	**93**	**0.0016**	**0.47**

Source: Technical Appendix P, Air Quality



5.3 Water Resources

A summary of the potential effects of the alternatives on water resources is presented in Table 5.3-1.

5.3.1 Hydrology

5.3.1.1 Alternative 1—Existing Conditions

Under Alternative 1—Existing Conditions, the river hydrograph would remain the same as the existing conditions described in Section 4.4.1 (Hydrology) and in the 1995 and 1998 Biological Opinions, and would follow the flow augmentation schedule to meet the 85 to 100 thousand cubic feet per second (kcfs) lower Snake River target. Flow depths would remain relatively constant throughout the year and range from about 20 feet in the tailwater areas to over 100 feet at the dams. The surface area of the lower Snake River of approximately 33,236 acres would remain the same. Because the existing operations do not provide flood control downstream, the current operations would not affect flood control.

5.3.1.2 Alternative 2— Maximum Transport of Juvenile Salmon and Alternative 3—Major System Improvements

Under these alternatives, the volume of water moving through the lower Snake River would not change from Alternative 1—Existing Conditions, which is based on the 1995 and 1998 Biological Opinions and would follow the flow augmentation schedule to meet the 85 to 100 kcfs lower Snake River target. The only slight differences between Alternatives 2 and 3 would be the travel time of the water.

Table 5.3-1. Summary of Potential Effects of the Alternatives on Water Resources

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Hydrology	No change from current conditions.	Slight decrease in water travel time or slight increase in water velocity.	Same as Alternative 2.	• Increase in water velocities. • Reduced surface area. • Flow depths would vary seasonally. • Increase in amount of overbank areas available for flood water storage. • Increase in sediment transport due to higher velocities for first 5 years until scouring stabilizes.
Water Quality—Sediment	No change from current conditions	Same as Alternative 1.	Same as Alternative 1.	• 50 to 75 million cubic yards of material could move downstream. Redeposited, materials could affect water withdrawal intakes and cause a short-term disruption in the food supply for bottom-feeding aquatic organisms. • Suspended sediment from moving materials could result in TSS concentrations that could adversely affect aquatic organisms and other beneficial uses during the first 2 years after dam breaching.
Water Quality—Temperature	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• Water temperatures would likely warm up faster early in the season and be higher, but cool down faster in early fall (see Table 5.3-2).
Water Quality—Contaminants	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• Manganese would exceed its criteria for thresholds in the water column.
Water Quality—Dissolved Gases	Planned improvements under Alternative 1 should result in reduced TDG levels.	TDG levels should decrease due to decreased voluntary spill.	TDG levels should decrease slightly due to additional planned improvements.	• There would be no spill, so TDG levels would be considerably lower and should remain stable and under the 110 percent threshold.

Under all the alternatives, the water travel times would decrease (or water velocity would increase) through the lower Snake River. The relative reservoir refill times that reflect water travel times are displayed in several charts in Technical Appendix F, Hydrology/Hydraulics and Sedimentation.

5.3.1.3 Alternative 4—Dam Breaching

Breaching the four lower Snake River dams would return this reach of the river to an unimpounded state. Because the four lower Snake River hydropower facilities are currently operated as run-of-river, the volume of water flowing through the system would not change. However, the water velocities would be greatest under this

alternative. Water depths and surface area would be significantly different under Alternative 4—Dam Breaching compared to Alternative 1—Existing Conditions. As a result of dam breaching, the surface area of the Snake River would be reduced from 33,254 acres to 19,464 acres, or almost half of the existing conditions. Flow depths would vary seasonally. During a typical spring runoff period (120 kcfs), average flow depth over a cross section would be about 25 feet compared to 15 feet during a typical flow condition. Unlike the current condition, flood stages would be much greater than average stages; therefore, the overbank areas available for flood water storage are greater under the dam breaching condition than under the existing condition. The additional flood storage would increase flood attenuation. The long-term indirect effects of higher velocities include the greater sediment transport. The greater velocities and lesser flow area would result in greater suspended sediment concentrations until the reservoir bed deposits have scoured downstream during the first 5 years following breaching. The effects of sedimentation from this alternative are described in Section 5.3.2 (Water Quality).

5.3.2 Water Quality

The discussion of potential impacts to water quality parameters focuses primarily on those parameters that are most likely to be affected by Alternative 4—Dam Breaching. The primary water quality parameters discussed include sediment; dissolved gases; temperature; and contaminants such as manganese, dioxin toxic equivalency quotient (TEQ), and total DDT. These parameters are the most significantly affected by the alternatives and are most relevant to the beneficial uses of the water (see Technical Appendix C, Water Quality for additional details). In addition, the removal and decommissioning of the dams would result in the removal of hazardous materials, substances, and chemicals that are used for current maintenance of the dams. Those materials would be removed in ways to minimize any potential hazards to the river and all waste would be disposed following regulatory requirements for the disposal of those materials.

Under current reservoir conditions, compounds are bound to sediment and organic matter and are present in the pore water (water between sediment particles) and open water. The release of impounded water and sediment during the drawdown would disrupt existing conditions in the reservoirs and the lower Snake River and Columbia River. Changes in water quality parameters such as temperature, pH, hardness, alkalinity, and salinity can alter the toxicity and degradation rate of some of the compounds that are currently in the water and sediments. Also, organic compounds can become biologically available when sediments are disturbed. Once liberated, it is unknown what the interdependent and interrelated reactions of multiple contaminants in the system would be. Impacts to the aquatic system in the lower Snake River and Columbia River systems will change as the physical and chemical properties of water and sediment changes following drawdown.

5.3.2.1 Sediment (Turbidity and Total Suspended Solids)

Alternatives 1, 2, and 3

Under Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, and Alternative 3—Major System Improvements, Lower Granite Reservoir would continue to capture the current average annual sediment load of 3 to 4 million cubic yards per year that the lower Snake River is carrying due to various basin runoff processes. The sediment stored behind each of the dams would remain the same except at Lower Granite, which would continue to receive its annual sediment load.

Alternative 4—Dam Breaching

Breaching of the four lower Snake River dams would allow the annual sediment load of 3 to 4 million cubic yards to be carried downstream to Lake Wallula (reservoir behind McNary Dam), where the majority of incoming sediment would likely be deposited. The very finest silts and clays would be carried as suspended sediment downstream through Lake Wallula, with their ultimate destination likely being the Lower Columbia estuary or the Pacific Ocean.

Recent sediment volume estimates developed by the Hydrology Branch of the Corps, Walla Walla District indicate that approximately 100 to 150 million cubic yards of sediment has accumulated behind the four lower Snake River dams. In addition, approximately 50 percent of this previously deposited sediment is expected to erode and move downstream within the first few years following dam breaching, particularly during peak flow periods (Corps, 1998a). This translates to about 50 to 75 million cubic yards of material that could move downstream. Approximately one-half of this eroded material is expected to settle out downstream in Lake Wallula during the 2 years following dam breaching. Lake Wallula is created by McNary Dam which is the first dam downstream on the Columbia from the Snake River confluence.

The eroded material would most likely be redeposited in Lake Wallula between the Snake River and Wallula Gap. Technical Appendix F, Hydrology/Hydraulics and Sedimentation (Plates 8-12) shows the qualitative predictions of sediment inundation in Lake Wallula. Because Lake Wallula extends to Ice Harbor, the very coarsest cobble materials could be initially deposited in the vicinity of Ice Harbor Dam, although they could later be subject to re-suspension and further transport downstream into Lake Wallula. Since these materials were once able to be previously deposited behind the lower Snake River dams, and since the flow velocities in Lake Wallula are generally slower than the Snake River's velocity, it is very likely that most of these sediments would also be deposited in Lake Wallula rather than being transported downstream of McNary Dam. The sediment exposed on the reservoir bottom after dam breaching would be subject to erosion from wind and precipitation and could eventually be transported downstream to Lake Wallula.

It is difficult to estimate the volumes and locations in which the various sized particles that make up the accumulated sediment will be redistributed downstream.

The previous System Operation Review (SOR) modeling indicated that most of this sediment would be re-deposited in the upper end of McNary pool between River Mile (RM) 320 and 325 on the Columbia River and RM 0 and 10 on the lower Snake River. Bathymetry data from 1934 indicate that quantity of sediment annually could likely deposit within each arm of the highly braided channel resulting in blockage that would require mechanical dredging for adult passage. The maximum accumulation rate was estimated to be approximately 47 pounds per square foot (lb/ft^2) (BPA et al. 1995). The location of the maximum would be at the confluence. The accumulation at McNary Dam was estimated to be approximately 10 times less than the maximum.

As a rough estimate, the average depth of sediment deposited in McNary pool could range between 1.7 and 2.5 feet, assuming the sediment is equally distributed throughout the impoundment. Realistically, the eroded sediment will not be equally distributed throughout the waterbody and will most likely be contained and deposited within the main river channel within the impoundment or along the eastern shoreline downriver to the north of the Walla Walla River where most sediment currently accumulates. Assuming that one-third of the area in the McNary pool represents the primary deposition zone, the depth of the new sediment could be as much as 4.2 feet. This potential depth of material is not likely to present navigation problems because most of the sediment would re-deposit in coves near the shoreline and not near the center where most of the McNary pool is greater than 65 feet deep. However, this could present problems with existing water withdrawal intakes, including those used for drinking water supply. In addition, redeposited sediment would likely cover large areas of benthic habitat, which could cause a major short-term disruption in the primary productivity and food supply for benthivores and other bottom feeders.

Suspended sediment, turbidity, and the downstream aggradation of the sediment stored in the lower Snake River reservoir beds are primary water quality concerns associated with drawdown. Potential mobilization of these stored sediments during the initial drawdown period may result in total suspended solids (TSS) concentrations that could adversely affect aquatic biota and other beneficial uses. For example, the increased turbidity can adversely affect both primary food production (i.e., phytoplankton and attached benthic algae growth) and fish feeding efficiency. In addition, depending on the magnitude of the TSS concentrations, impairments to other biological functions such as respiration (i.e., gill clogging) and reproduction are possible.

The previous SOR modeling efforts to predict suspended sediment and turbidity used 25 milligrams per liter (mg/l) TSS as a threshold for protection of fish (BPA et al., 1995). It compares reasonably well with average TSS levels observed in the lower Snake River reach based on the 1997 data (reflects background conditions). Under Alternative 4— Dam Breaching, sediment concentrations during the first year following breaching were predicted to exceed the 25 mg/l threshold approximately 36 percent of the time (131 days). The average exceedance for the next 15 years was estimated to be 25 percent of the time (91 days). This compares to no exceedances under the existing condition.

During the 1992 drawdown test conducted in the Lower Granite Reservoir, suspended sediment concentrations were observed to be as high as 2,000 mg/l (Corps, 1992) during a time when peak flow conditions and rainfall events were not encountered. During the tests, water levels were lowered 33 feet, which exposed substantial mudflats along the shoreline of the reservoir. Under the proposed drawdown, a more extensive series of mudflats would be exposed, vulnerable to erosion and transport downstream, especially during peak flow periods. TSS concentrations could be reasonably expected to be as high as 9,000 mg/l at Ice Harbor due to breaching until the new channel bed and banks stabilize and equilibrate with the flow regime.

5.3.2.2 Temperature

Alternative 1—Existing Conditions

This alternative represents a continuation of the current system operations as they have been implemented since the issuance of the 1995 Biological Opinion, including flow augmentation up to 427 thousand acre-feet (KAF).

The previous SOR temperature modeling predicted the number of days exceeding a temperature threshold of 63 degrees Fahrenheit (°F) at Lower Granite under existing conditions. This threshold was established in the SOR because temperatures higher than this are thought to impair the reproductive success of anadromous fish (Corps, 1995a). The predicted annual average number of days exceeding the threshold was 78 days. Based on review of the number of days with observed water temperatures above 63°F, the most recent data from 1994, 1995, and 1997 were slightly higher than these predictions. In 1994, a very low flow year, there was an estimated 110 to 115 days with water temperatures above the 63°F SOR threshold. In 1995 (a cool summer season) and 1997 (high flow year), the number of days exceeding the 63°F SOR threshold ranged from approximately 80 to 90 days.

The historical data presented in Technical Appendix C, Water Quality indicate that water temperatures above 68°F (the water quality standard) also commonly occurred prior to impoundment conditions. The data show that the river was warmer than the existing series of reservoirs. The data the Corps has published since the dams became operational show a general lowering of water temperatures in the reservoirs, and a more dramatic decrease since 1992 when cool water releases from Dworshak began. According to the Corps' measured data, the number of days exceeding 68°F has decreased since the reservoirs were developed. The data also show that the main factor influencing temperatures in the reservoirs is the temperature of inflow from the Clearwater and Snake rivers.

Alternative 2— Maximum Transport of Juvenile Salmon

Since flow operations will remain the same as under Alternative 1—Existing Conditions, this alternative is not expected to produce any discernable changes in water temperatures relative to existing conditions.

Alternative 3—Major System Improvements

Similar to Alternative 2—Maximum Transport of Juvenile Salmon, this alternative is not expected to cause any major changes in water temperature relative to existing conditions. The major fish passage improvements proposed under this alternative are not likely to change water temperatures.

Alternative 4—Dam Breaching

Breaching the dams would produce a dramatic change in the volume and heat storage capacity of open water in the lower Snake River. As previously modeled by Bennett et al. (1997), maximum temperatures during the summer months of July through August are anticipated to be approximately 3.6°F to 9.0°F higher under Alternative 4—Dam Breaching, approaching 78.8 °F to 80.6°F. The WQRSS water temperature modeling results (see Technical Appendix C, Water Quality) also suggest that water temperatures during low flow years in the lower Snake River could reach higher summer peaks under Alternative 4—Dam Breaching than under the existing impounded river condition. Under wet and average hydrometeorological conditions, peak summer temperatures are projected to be similar to those observed under existing conditions.

The existing reservoir system also tends to warm slowly in the spring and cool slowly in the fall due to the larger volume of water and larger heat capacity of the impoundments compared to a free-flowing system. Under Alternative 4—Dam Breaching, with less open water area and shallower depths, water temperatures would likely warm up faster early in the season and be higher but also cool down faster in early fall. Recent model results predict a more dramatic cooling (Table 5.3-2) (see Technical Appendix C, Water Quality for discussion of model assumptions).

Table 5.3-2. Comparison of Temperature Modeling Results

WQRSS Model[1/]	EPA Model[2/]	MASS2[3/]
Water temperatures would likely warm up faster early in the season and be higher, but cool down faster in the early fall. For dry years, Water temperatures would drop to 59°F at end of summer approximately 15 days earlier than under impounded conditions. For high flow years, water temperature would drop to 59°F at end of summer approximately 5 days earlier than under impounded conditions.	Predicted magnitude of exceedance of 68°F is greater in impounded condition than with dams removed. The model predicts stream water temperatures to exceed 68°F at the confluence with the Columbia River 1 to 6 percent of the year under a natural river scenario compared to 6 to 11 percent of the year with the dams in place.	Reservoirs decrease the water temperature variability by keeping water cooler later in the spring and warmer later in the fall compared to the natural river condition. Variability in water temperatures is much greater under the natural river drawdown scenario during the peak growing season (June through September).

1/ Normandeau Associates, Inc., 1999
2/ Yearsley, 1999
3/ Perkins and Richmond, 1999

Under Alternative 4—Dam Breaching, water temperatures were predicted to drop to 59°F at the end of the summer season approximately 15 days earlier than observed during 1994, a low flow year. During a high flow year, such as in 1997, the difference between the predicted date for water temperatures to drop to 59°F and the observed date under existing conditions was closer to 5 days. Thus, the earliest cooling of water temperatures at the end of the summer season under Alternative 4—Dam Breaching would occur during low flow years.

In another study, the EPA (1999) model predicts that Alternative 4—Dam Breaching would produce fewer temperature threshold exceedances greater than 68°F than under the current operating conditions. Under Alternative 4, temperatures are expected to exceed 68°F by approximately 1.8°F from the confluence of the Clearwater and Snake rivers to Ice Harbor, with the temperature remaining relatively constant throughout this reach. The existing impounded conditions stated in this model showed water temperature exceedances as approximately 1.8°F at the confluence and increase downstream to 3.1°F at Ice Harbor. The EPA model also predicts that the frequency of exceedance over 68°F under Alternative 4—Dam Breaching would follow the same trends under the existing conditions (see Table 5.3-2).

5.3.2.3 Contaminants

Some contaminants are readily attached or adsorbed to sediments by physical or chemical bonding. A sediment contaminant study was conducted to determine the effects of dam breaching on the distribution of organic and inorganic chemical constituents in sediment and the water column (Foster Wheeler Environmental, 1999a). Two organic chemical constituents of concern—dioxin TEQ and total DDT—were found in the sediments. The analysis showed that neither dioxin TEQ or total DDT would exceed their sediment quality criteria under Alternative 4—Dam Breaching. Manganese was the only inorganic chemical of concern found in the water column in this study. Analytical data exhibited manganese concentrations in excess of odor and taste threshold criteria but not at levels of concern for toxicity or health effects. The manganese analysis was based on aesthetic values of taste and odor, throughout the lower Snake River, and in the Columbia River upstream of the Port of Hermiston municipal water diversion near McNary Dam to the mouth of the Snake River.

5.3.2.4 Dissolved Gases

The regulatory limit for total dissolved gas (TDG) saturation has been modified in recent years by the regional regulatory agencies to allow for spill for juvenile salmonid passage, rather than passage through turbines or collection and transport. It is the Corps' policy to try and meet the 110 percent TDG, but this is difficult to accomplish because of spill for fish, spring runoff, and other constraints.

Alternative 1—Existing Conditions

Under this alternative, current system operations would continue as they have since the issuance of the 1995 Biological Opinion, including flow augmentation up to 427 KAF. The addition of end bay deflectors at Lower Monumental and Little Goose

dams is assumed for this alternative. Modified deflectors at Lower Monumental, Little Goose, and Lower Granite are also assumed as part of this base case.

Spill to 120 percent TDG would be executed as defined in the 1995 and 1998 Biological Opinions. Forced spill would likely be similar to operations from 1996 to 1998. Spill caps could remain at current levels or be increased as TDG production is reduced due to spillway improvements. The increases in spill discharge to attain 120 percent TDG are estimated to be from 45 kcfs to 68 kcfs at Lower Granite, from 48 kcfs to 68 kcfs at Little Goose, and from 43 kcfs to 68 kcfs at Lower Monumental. The gas abatement improvements used with current voluntary spill discharges would result in TDG levels of 112 to 115 percent. TDG gas levels of 130 to 140 percent during times of involuntary spill would exceed 110 percent for extended periods.

Alternative 2—Maximum Transport of Juvenile Salmon

This alternative assumes that the juvenile fishway systems would be operated to maximize fish transport and that voluntary spill would not be used. As a result, elevated dissolved gas concentrations from upstream (the Clearwater River and middle Snake River) would decrease through the lower Snake River. The addition of end bay deflectors at Lower Monumental and Little Goose dams is assumed for this alternative.

Under this alternative, voluntary spill for fish only remains for non-collected smolts at Ice Harbor. The Corps anticipates, under this alternative, a spill discharge cap of 110 percent or less. Forced spill for peak flow events on the Snake River would likely be similar to 1996 to 1998 operations and could exceed 130 to 140 percent in tailwaters for several weeks system-wide. Levels of TDG at Lower Monumental and Little Goose would be reduced somewhat due to the addition of end bay deflectors.

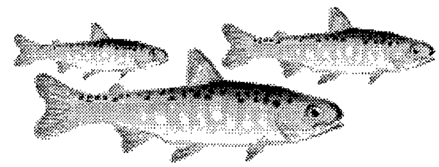
Alternative 3—Major System Improvements

The addition of end bay deflectors at Lower Monumental and Little Goose is assumed for this alternative.

Under this alternative, only a small spill discharge would result from dewatering of the surface bypass collector over a spillway bay. However, this would only lead to small increases in TDG loading to the system. A proportional increase in this source would occur as river flows decrease. Voluntary spill for fish would only remain for non-collected smolts at Ice Harbor under this alternative. Spill would likely be similar to 1996 to 1998 operations. Under this alternative, TDG during involuntary spill conditions during peak flows in the spring could still exceed 130 to 140 percent in tailwaters for several weeks system-wide. TDG at Lower Monumental and Little Goose would be reduced somewhat due to additional end bay deflectors.

Alternative 4—Dam Breaching

Under this alternative, there would be essentially no more hydraulic head at the four lower Snake River dams and therefore no spill. As plunge pools form during the development of a stable channel morphology under a different flow regime, geographically localized TDG above 110 percent is possible infrequently and for short durations of time.



5.4 Aquatic Resources

5.4.1 Anadromous Fish

The 1995 Biological Opinion (NMFS, 1995) established measures to be considered to meet the survival and recovery goals of Snake River salmon species listed under the ESA, as defined under the Draft Recovery Plan (Schmitten, 1995). In the 1995 Biological Opinion, the National Marine Fisheries Service (NMFS) concluded that major changes in the operation and configuration of the Federal Columbia River Power System (FCRPS) needed to be evaluated with the goal of increasing salmon survival. Required actions in this document called for detailed analysis of alternative configurations and operations of the four lower Snake River Federal dams. The direction of the 1995 Biological Opinion was to consider if dam breaching or some other alternative would result in adequate survival and recovery of these stocks. The Corps has responded to the 1995 Biological Opinion by conducting the Lower Snake River Juvenile Salmon Migration Feasibility Study and by preparing this FR/EIS.

This section presents the results of analyses directed at determining both the effectiveness of the alternatives at meeting the goals described in the 1995 Biological Opinion, and overall effects on all potentially affected anadromous stocks. A summary of the potential effects of the alternatives on anadromous fish is presented in Table 5.4-1. The analysis is divided into five subsections. The first four subsections address the

Table 5.4-1. Summary of Potential Effects of the Alternatives on Anadromous Fish

Alternative 1—Existing Conditions
Based on the NMFS Cumulative Risk Initiative (CRI) analysis (see Section 5.4.1.6), the chance of extinction for some Snake River spring/summer chinook index stocks in the short term (within 10 years) under current conditions is relatively high (up to 15 percent). However, under these conditions, there is a low chance of extinction for fall chinook and steelhead (less than 0.01 percent). The long-term (within 100 years) chance of extinction increases substantially—33 to 88 percent for spring/summer chinook index stocks, 6 percent for fall chinook, and 93 percent for steelhead.
CRI analysis indicates that currently implemented hydrosystem improvements, relative to those in place in the late 1970s, have substantially benefited juvenile and adult salmonid survival and likely prevented the extinction of Snake River spring/summer chinook and possibly other stocks.
PATH analyses (see Section 5.4.1.5) indicate that future salmon escapements of spring/summer chinook would be slightly less than the NMFS survival criteria (i.e., minimal acceptable escapement) and just equal to recovery criteria (threshold level escapement for NMFS defined recovery). PATH results are dependent on assumptions about additional mortality including differential delayed transport mortality (i.e., mortality that occurs to transported fish after they are released that does not occur to untransported fish) and extra mortality, which could be related to passage (either in-river or transported) through the hydrosystem after they have left the hydrosystem corridor. Other sources of additional mortality may be caused by factors independent of the hydrosystem, such as reduced stock viability and ocean conditions. Also, recent data presented by NMFS suggest delayed transport mortality may be lower than that used in the PATH models.
PATH analyses for fall chinook produced varied results that depended on which of four sets of assumptions were considered for delayed transport mortality. Survival criteria were met for all four assumptions used, but recovery criteria were only met for two of the four. Results for steelhead could not be modeled in the same manner, but would likely be similar to, but better than, spring/summer chinook salmon. Sockeye salmon were not modeled but would likely be similar to other species.
PATH results indicated that the chance of meeting NMFS survival and recovery criteria for spring/summer chinook, fall chinook, and steelhead under Alternative 1 would likely be the same or slightly better than Alternatives 2 and 3, but mostly worse than Alternative 4.
Low to moderately high direct (which includes in-river and transport) passage mortality, (lowest for spring/summer chinook; highest for fall chinook) would occur with Alternative 1. Direct mortality would be slightly higher than Alternatives 2 or 3 for all stocks and much lower for at least spring/summer chinook and steelhead than Alternative 4. Results for direct passage mortality for fall chinook are unclear. Overall direct passage mortality is primarily influenced by the portion of fish transported. For example, the estimated direct mortality of transported fish is about 2 percent. Therefore, when the portion of fish transported is higher, the direct passage mortality is lower.
Harmful dissolved gas concentrations effects would be slightly worse under Alternative 1 than Alternatives 2 or 3 and, during peak flows, much worse than Alternative 4 for Snake River ESA-listed salmon and steelhead stocks.
Survival of adults during upstream migration would remain in the high 90 percent range per facility for spring/summer chinook, sockeye, and steelhead, and would be lower for fall chinook due to straying and fallback. These levels would be similar to Alternatives 2 and 3, but may be the same or lower than Alternative 4.
No change in effects to Columbia River (non-Snake-River) salmon and steelhead stocks would occur, including listed stocks.
Pacific lamprey and American shad would continue to have passage losses in the Snake River.

Table 5.4-1. Summary of Potential Effects of the Alternatives on Anadromous Fish

Alternative 2—Maximum Transport of Juvenile Salmon
The CRI analysis did not distinguish between Alternatives 2 and 3, so the findings are assumed to apply to both. CRI analysis indicates that maximum transport would slightly reduce the chance of extinction by improving conditions over Alternative 1. However, this improvement would not be adequate to meet the NMFS-designated threshold risk levels.
PATH model results indicate a slightly lower chance of meeting the NMFS spring/summer chinook and possibly steelhead survival and recovery criteria than under Alternative 1, while fall chinook is the same. Alternative 2 would have a slightly lower chance of meeting the NMFS survival criteria than Alternative 4 for all stocks, and much lower chance for spring/summer and fall chinook (for three of four sets of hypotheses) for recovery criteria than Alternative 4. It should be noted that the PATH results are highly dependent on assumptions about the degree of additional mortality attributed to the hydrosystem after juveniles have left the river.
This alternative would have slightly reduced direct passage mortality (including both in-river passage and transport) relative to Alternative 1 and slightly higher mortality than Alternative 3 because of the relative portion transported. For the same reasons, the results also indicate there would be much lower direct passage mortality, at least for spring/summer chinook and steelhead and possibly fall chinook, than Alternative 4.
Harmful dissolved gas concentrations effects would be similar to Alternative 3, slightly better than Alternative 1, but during peak flow periods, they would be much worse than Alternative 4 for Snake River stocks.
Survival of adult fish during upstream migration would remain in the high 90 percent range per facility for spring/summer chinook, sockeye, and steelhead, and would be lower for fall chinook due to straying and fallback. These levels would be similar to Alternatives 1 and 3, but may be the same or lower than Alternative 4.
No change in effects to other Columbia River salmon and steelhead stocks, including listed stocks is predicted.
Pacific lamprey and American shad would continue to have passage losses in the Snake River.
Alternative 3—Major System Improvements
CRI analysis did not differentiate between Alternatives 2 and 3 (see Alternative 2). Because the increased transport showed reduced risk of extinction in the CRI analysis, Alternative 3 should reduce the chance of extinctions slightly more than Alternative 2 because more fish would be transported.
The PATH model results were nearly the same as Alternative 2 indicating a generally similar chance of meeting the survival and recovery criteria for spring/summer chinook (the same for survival, less for recovery) and steelhead than under Alternative 1, but much worse for recovery criteria than Alternative 4. For fall chinook, Alternative 3 would be slightly better than Alternative 2 for recovery criteria, and relatively variable for the survival criteria depending on delayed transport mortality hypothesis used in the models. Results are highly dependent on assumptions about the degree of additional mortality attributed to the hydrosystem after juveniles have left the river.
Under Alternative 3, there would be slightly reduced direct passage mortality (in-river plus transport) relative to Alternative 2 because of the greater portion transported. There would be much lower direct passage mortality, at least for spring/summer chinook and steelhead and possibly fall chinook than Alternative 4 for the same reasons.

Table 5.4-1. Summary of Potential Effects of the Alternatives on Anadromous Fish

Alternative 3 (continued)
Harmful dissolved gas concentrations effects would be similar to Alternative 2, slightly better than Alternative 1, but much worse than Alternative 4 during peak flow periods for Snake River stocks.
Survival of adults during upstream migration would remain in the high 90 percent range per facility for spring/summer chinook, sockeye, and steelhead, and lower for fall chinook due to straying and fallback. These levels would be similar to Alternatives 1 and 2, but slightly better due to increased turbine diversion screening. Survival may be the same or lower than Alternative 4.
No change in effects to other Columbia River salmon and steelhead stocks, including listed stocks.
Pacific lamprey and American shad would continue to have passage losses in the Snake River. Some benefit would occur for Pacific lamprey in the Snake River if new screening facilities increase diversion from turbines.
Alternative 4—Dam Breaching
The CRI analysis indicates that while dam breaching is better at reducing the extinction risk of spring/summer chinook stocks than other alternatives, it may still be inadequate by itself to reduce the extinction risk to NMFS proposed threshold levels. The risk of extinction could be reduced to threshold levels for fall chinook and steelhead with this alternative, but only if survival below Bonneville Dam is increased by at least 20 percent as a result of this action. Sockeye were not assessed with this analysis but would likely have similar benefits as other stocks.
Based on CRI analysis, dam breaching alone could only result in recovery (acceptable extinction risk) if it resulted in extremely large survival increases below Bonneville Dam (almost double the current survival rate). Additional habitat improvements and harvest reduction by themselves would not result in achieving extinction risk threshold levels for spring/summer chinook. The model results suggest that for spring/summer chinook, a combination of dam breaching, habitat improvements, and harvest reduction would be needed to approach achieving these levels.
The CRI life-stage analysis indicates that large increases in overall survival could result from relatively small reduction in mortality during the first year of life, such as in freshwater juvenile stage or the estuarine/early ocean stage. It is unknown whether these types of changes could be made.
Both steelhead and fall chinook, based on CRI analysis, could reach acceptable levels of extinction risk with just reduction in harvest rates and no changes in the current hydrosystem.
PATH analyses indicate that this alternative is more likely than any other alternative to meet survival and recovery criteria of listed species. It would meet NMFS survival and recovery criteria for spring/summer chinook, fall chinook, and steelhead. NMFS has indicated, however, that PATH analyses could not determine if breaching was necessary or sufficient for recovery. The difference between this and other alternatives in meeting the criteria are highly dependent on the assumptions about the effects of delayed transport mortality and extra mortality. Should the relative effect of the hydrosystem on these factors be lower than assumed, then the differences among the alternatives would be reduced and breaching would offer only a slight improvement in survival over current conditions.
Both the CRI and PATH analyses indicate that further improvements in the hydrosystem passage system are unlikely to recover listed Snake River stocks unless there is an improvement in juvenile fish survival downsteam of Bonneville Dam, either through such factors as improved fish conditions or improved timing of entry into the ocean.

Table 5.4-1. Summary of Potential Effects of the Alternatives on Anadromous Fish

Alternative 4 (continued)
Short-term effects would be mostly adverse relative to current conditions for Snake River stocks. Adverse effects would occur from elevated suspended sediment (e.g., reduced feeding, direct mortality of juveniles). There could be impedance of juvenile and adult migration with some extended disruption to adult migration from sediment (for primarily 2 to 3 years). Rearing habitat quality for juvenile fall chinook would be reduced, but there would be some benefit from increased juvenile migration rates and reduced dissolved gas.
There could be some short-term adverse effects on other Columbia River stocks that migrate through McNary pool from increased suspended sediment and burial of rearing habitat. There may also be fall and spring adult migration delays for primarily 2 to 3 years during and following dam breaching. Reduced subyearling chinook salmon rearing habitat quality in McNary pool may occur.
Long-term benefits would likely reduce in-river juvenile passage mortality for all Snake River salmon and steelhead stocks through the Snake River reach. Adult passage mortality may decrease or remain unchanged. Elimination of dam mortality and possible reduced predation in the Snake River reach, and an increased juvenile migration rate may be a benefit for all stocks. Improved river rearing habitat and increased fall chinook river spawning habitat may take more than 2 to 5 years to develop. Reduced adverse effects of dissolved gas supersaturation in the Snake River would occur.
Some long-term potentially adverse effects include the loss of fish transport from the Snake River which would increase the direct passage mortality (in-river plus transport) because of the high direct survival rate (98 percent) of fish in barges, particularly for spring/summer chinook and steelhead. There also is an increased risk of stray Columbia River fall chinook stocks mixing with native stocks and spawning in the Snake River, possibly reducing the native fall chinook stock viability.
Long-term benefits for other Columbia River salmon and steelhead stocks, including federally listed stocks (mostly for those passing McNary pool) would include reduced dissolved gas supersaturation and increased spring turbidity, which may reduce predation.
Pacific lamprey migration survival in the Snake River would improve, while American shad use may decrease due to loss of reservoirs. Overall effects to Columbia River stocks of these species would be slight.

effects of each alternative on all anadromous stocks, with emphasis on listed Snake River salmon and steelhead. The analysis in these subsections is primarily qualitative in nature and does not directly estimate how closely each alternative could achieve the goals of the 1995 Biological Opinion and Draft Recovery Plan (NMFS, 1995; Schmitten, 1995). The qualitative assessment of each specific alternative on the listed Snake River stocks, and on other anadromous fish that could be affected by each alternative, is based on literature and extensively on the U.S. Fish and Wildlife Coordination Act Report (Technical Appendix M) and the summary of the Anadromous Fish document provided by NMFS (Technical Appendix A, Anadromous Fish). Section 5.4.1.5, Model Analysis of All Alternatives, is a more quantitative evaluation of the likelihood of each alternative meeting the jeopardy standards of the 1995 Biological Opinion for the Snake River listed stocks and is based on the NMFS analysis as presented in Technical Appendix A, Anadromous Fish. The NMFS analysis, in turn, depended heavily on documents developed by the regional process known as Plan for Analyzing and Testing Hypotheses (PATH) (Marmorek and Peters, 1998a, b; Marmorek et al., 1998a, b; Marmorek et al., 1996) and NMFS, Cumulative Risk Initiative (CRI) analysis.

The PATH analysis is based primarily on an extensive review of the best available data together with modeling of the effects of hydrosystem operation and configuration under each alternative on downstream and upstream passage survival (i.e., lifecycle modeling) and the subsequent effects of that and other factors on the long-term population trend. NMFS performed additional modeling for use in its evaluations. This additional modeling has been designated the CRI. It was developed by NMFS' Northwest Fisheries Science Center. The modeling is being used to evaluate the sensitivity of changes in a specific life-history stage and the relative effect of changes in other life-history stages on achieving biological goals and objectives. The analysis will determine if one or multiple H combinations (habitat, hatcheries, harvest, and hydropower) exist to achieve the biological objectives related to recovery of ESA-listed species.

Although the NMFS analysis presented in Technical Appendix A, Anadromous Fish includes additional alternatives, this section discusses only the four alternatives under evaluation in this FR/EIS. The FR/EIS alternatives are: Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, Alternative 3—Major System Improvements, and Alternative 4—Dam Breaching.

5.4.1.1 Alternative 1—Existing Conditions

The impact assessment for Alternative 1—Existing Conditions emphasizes potential effects on the listed Snake River salmon and steelhead. Potential effects to other Columbia River (non-Snake River) anadromous salmonids and other anadromous stocks are discussed separately and in less detail.

Many factors affect salmon and steelhead in the Snake River System independent of the construction and operation of the four lower Snake River dams. Notably, many other dams constructed upstream of the lower Snake River dams had very significant effects on runs of all of the currently listed species, in many cases reducing the potential for production to a small fraction of the historical levels. Dam construction upstream of Lower Granite Dam has caused the overall loss of about 46 percent of river miles of salmon spawning and rearing habitat in the Snake River System, including the mainstem

Snake and Clearwater rivers (Appendix A of Corps et al., 1993). The greatest relative loss has been for fall chinook salmon, which is estimated to have lost most of its total historical spawning habitat from construction of the dams from Hells Canyon Dam upstream (Waples et al., 1991).

The construction and operation of dams on the lower Snake River have affected anadromous salmonids in many ways. Dams change the flow rate and water velocity through the reach, affecting migration; present obstacles and sources of injury for fish attempting downstream and upstream passage; affect juvenile fish transported by truck or barge to avoid direct mortality; increase the danger of dissolved gas supersaturation; increase the habitat for predators of juvenile salmonids; alter rearing habitat; modify the seasonal temperature regime; and inundate spawning habitat. Dams have direct, quantifiable effects on salmonids such as direct mortality from turbine passage, as well as indirect effects such as modification of estuary arrival times for juvenile fish (Marmorek et al., 1996). These effects can generally be grouped according to their effects on juvenile or adult Snake River salmon and steelhead.

Snake River Salmon and Steelhead

Effects on Juvenile Salmonids

Direct and indirect effects on salmonids from Alternative 1—Existing Conditions are presented by the primary factors associated with operation of the Lower Snake River Hydropower Project: flow and water velocity, dam passage, transportation, dissolved gas supersaturation, predation, and rearing migratory habitat. Where information on the effects of these factors is not clear, the range of data and interpretations is provided.

Juvenile fish from the Snake River either move to the estuary by passing through all reservoirs and dams (in-river migration) or they may be collected and transported by truck or barge at one of three dams on the Snake River or McNary on the mainstem Columbia River, and released below Bonneville Dam. While many individual factors affect overall survival (discussed in the following subsections), a summary of how overall direct in-river passage survival of juvenile spring/summer chinook salmon has changed over time is shown in Figure 5.4-1. Preliminary survival estimates for 1999 indicate in-river passage survival in the range of 45 to 62 percent for spring/summer chinook salmon and 42 to 54 percent for steelhead for this same reach (Ledgerwood et al., 1999). This information indicates that current direct passage survival of spring/summer chinook salmon has increased in recent years and is at least as high as it was in the 1960s when only four dams instead of eight dams were in place for Snake River fish to pass on their way to the ocean (NMFS, 1999a). Under Alternative 1—Existing Conditions, it is expected that in-river passage survival should remain similar to the data from recent years. It should be noted that these passage survival values represent only direct passage survival of yearling chinook salmon and do not include any possible delayed effects to fish from passing through the hydro system or survival of transported fish.

When evaluating the overall mortality of juvenile fish, all stages of their life history should be considered. Mortality prior to passage of the first dam encountered can often be as high as 95 percent. Even though over 90 percent of eggs are fertilized, fry to smolt

mortality can make up a large part of the egg to smolt mortality; overall, 99.95 percent of the progeny of two adult spawners will die before they spawn, or the population will increase.

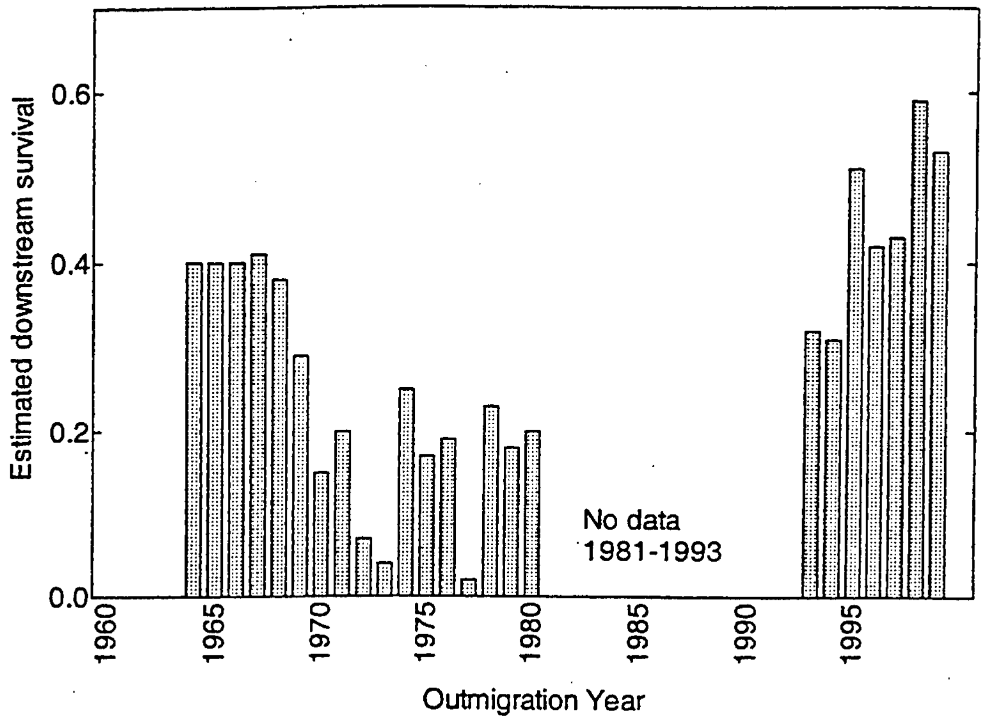


Figure 5.4-1. Estimated Survival (Estimates Based on Extrapolations Outside of Reaches Actually Measured) of Juvenile Spring/Summer Chinook Salmon from the Upper Dam on the Snake River to the Tailrace of Bonneville Dam (not including transported fish).[1/]

1/ From 1964 to 1967, juveniles passed Ice Harbor, McNary, The Dalles, and Bonneville dams. Additional dams were added in 1968 (John Day Dam), 1969 (Lower Monumental Dam), 1970 (Little Goose Dam), and 1975 (Lower Granite Dam). Data are from unpublished NMFS analyses (NMFS, 1999a).

Flow and Water Velocity

The development of dams and reservoirs has changed the lower Snake River from a free-flowing stretch to a 140-mile river reach of slack water with reservoirs that are wider and deeper than the original river. Upstream storage reservoirs have reduced flow peaks during the spring season. The net effect has been to reduce velocity and increase the time water takes to travel through this reach. Because juvenile salmon and steelhead are primarily passive in their migration, the change in velocity has affected the rate of downstream migration of juvenile salmonids.

Some records indicate that the rate of migration from the Salmon River in Idaho to below the Bonneville Dam area, under some conditions, has increased from 22 days (without lower Snake River dams) to 50 days (with lower Snake River dams) (Ebel, 1977). In contrast, while flow may affect movement upstream of Lower Granite Dam, fish that are collected and transported spend only about 2 days traveling from Lower Granite to below Bonneville Dam, independent of flow.

The delay in migration could affect the timing of arrival at the estuary for in-river migrating fish. The ability of juvenile salmonids to acclimate to salt water is dependent on their physiological condition, and these conditions are somewhat time- dependent along with size-dependent. Therefore, this delay in arrival at the estuary could affect their ability to physiologically transition to the marine environment. Also, the delay could subject fish to high water temperatures longer and increase the rate of predation.

The effects of flow were also examined relative to the effects on overall survival. Early studies conducted when the lower Snake River dams were being constructed indicated a correlation between downstream passage survival and flow (Sims and Ossiander, 1981). Other studies indicated that the quantity of flow affects travel time and smolt survival (Sims and Ossiander, 1981; Sims et al., 1983; McConnahan, 1990; Berggren and Filardo, 1993; DeHart, 1991; Petrosky, Unpublished Manuscript). The general positive relationship between flow and survival emerged primarily from early studies on the Snake River by Sims and Ossiander (1981) and later by Sims et al. (1983). The meaning of these results was clouded by the effects of dissolved gas and spill and also by high levels of debris at the dams that increased mortalities during some of the early study years (Steward, 1994; Williams and Matthews, 1995).

Adult returns have also been found to be related to the juvenile migration season flow and spill during which they outmigrated as smolts. Raymond (1979) found that the survival of smolts to adults was higher during years of higher flow and spill than during years with lower flows. Petrosky (1991) found a positive survival relationship from smolts to returning adults with increased flow years for some upper Snake River chinook salmon stocks during the 1977 to 1987 period. However, since 1977, the majority of Snake River spring/summer chinook salmon have been transported so that the effects of flow on survival may be from delayed effects of flows upstream of Lower Granite Dam or below Bonneville Dam (e.g., estuary or ocean plume) (NMFS, 1999a). It should also be noted that the period from 1977 to 1996 was a drought cycle, and that from 1986 through 1995, Snake River flows were below normal for 10 years in a row.

Results of these and other studies have led to general agreement that there is some positive relationship between increased flow and juvenile survival (Cada et al., 1997). However, the relationship is only a general one, and there is disagreement about the exact survival benefits of increased flow, particularly when flows are greater than moderate. Recent research has not demonstrated a flow/survival relationship by reach in the lower Snake River for spring migrants. Also, while there is a significant flow/survival relationship to summer migrants in the flowing portion of the Snake River upstream of Lower Granite Dam, this relationship is confused by a similar strong relationship to temperature and turbidity, which are also correlated with flow (NMFS, 1999a).

Other studies on effects of flow on survival have been equivocal. A multi-year study using passive integrated transponder (PIT)-tagged yearling juvenile chinook salmon and steelhead migrating during the spring freshet found varied effects of flow on survival through the lower Snake River and a portion of the Columbia River (Smith et al., 1998). The results indicated that travel time through the reservoirs was related to flow rate and that spill quantity and temperature also affected movement rate.

The migration rate of spring migrating juvenile salmonids has been shown to be partly dependent on the time within the migration period, with later fish migrating faster. In addition, results of the study showed a significant relationship between survival of chinook salmon and steelhead and average seasonal flow when all years in the study were combined. However, there was no significant relationship to flow rate and survival within a specific year (i.e., the flow rate individual fish encountered during a single year did not appear to significantly influence survival).

The quantity of flow could influence survival of juvenile Snake River fall chinook salmon, but this too is uncertain. Reservoirs in the system could also have reduced turbidity, which could decrease cover that provides protection from predators for migrating juveniles. Muir et al. (1999) found several factors that appeared to affect both travel time and survival of juvenile Snake River fall chinook salmon. They found that survival of Snake River fall chinook salmon to Lower Granite Dam was significantly related to flow, turbidity, and temperature. Survival was correlated to travel time in only 1 of 3 years of study, and travel time was not correlated with any physical factor in 2 of 3 years. Survival decreased with decreased flow, decreased turbidity, and increased temperature on an annual basis. Because these factors themselves were highly correlated, it is not possible to determine which was the major factor affecting survival.

In the reach from Lower Granite Dam to Lower Monumental Dam, a similar but less strong pattern was identified. Survival was again correlated to flow, temperature, and turbidity, but strong correlations existed only in 1 of 3 years. The year with the highest flow, 1997, actually resulted in lower survival of fish below Lower Granite Dam than the other 2 years; this was thought to be the result of the fish being smaller during migration (Muir et al., 1999).

Selected flow/survival relationships developed through past research are incorporated directly or indirectly into some of the models used by PATH to analyze the effects of the various alternatives (see Technical Appendix A, Anadromous Fish). The effects of flow on survival are incorporated into the results of these models for Snake River spring/summer and fall chinook salmon.

Under Alternative 1—Existing Conditions, flow augmentation would continue. It is possible that some of it could be terminated, however, because the current agreement on augmentation flow from the upper Snake River ends in 2000. As described in Section 2, flow augmentation would be provided during the spring and summer migration period, mainly to increase survival of migrating juvenile fish. This flow release is currently managed under the 1995 and 1998 Biological Opinions. There is a sliding scale for spring and summer flow objectives (April through August) dependant on annual availability of stored water. The timing of flow depends on several factors (e.g., fish abundance, available storage, and river temperature). The priority of flow augmentation for the Snake River is for summer migrating juvenile fall chinook salmon in July and

August, unless doing so would depart markedly from the spring flow objectives. The result is some balance of use for spring and summer flow needs and reservoir refill. Dworshak Reservoir has been used as part of the flow augmentation program. Releases from Dworshak create cooler water downstream. These releases can benefit survival of the juvenile Snake River fall chinook salmon stocks in the summer, although it could be detrimental to the Clearwater River stocks by extending the period before these fish are ready to migrate (Arnsberg and Statler, 1996; Connor et al., 1996). If increased flow increases survival, then flow augmentation should benefit the Snake River salmonid stocks.

Dam Passage

Submerged traveling screens (STSs) or extended submerged bar screens (ESBSs) divert migrating fish away from turbines at lower Snake River and most lower Columbia River dams (see Section 3.1.2.1). In recent years, designated spill has been used to bypass fish around dams in addition to the screen diversions.

Many of the fish diverted and collected from Lower Granite, Little Goose, and Lower Monumental dams on the Snake River, and McNary Dam (only summer migrants are transported here) on the Columbia River are transported downstream by barge or truck and released below Bonneville Dam. Most diverted fish are transported, except for PIT-tagged research fish that constitute the in-river treatment group. About 88 percent of all diverted fish were transported in 1996 from transportation facilities on the Snake and Columbia rivers (Hurson et al., 1999). The portion of fish transported is high; for example, 50 to 60 percent of spring/summer chinook salmon were transported in 1996 and 1997 (Marmorek et al., 1998a). A slightly higher portion of steelhead and likely a lower portion of subyearling fall chinook salmon were transported. The remaining portions either pass through the turbines or through the spillways.

Fish passing through the dam could be diverted by the screening bypass system where they could be either retained for transport or released back to the river below the dam. Some migrating juvenile fish die in bypass and transport facilities. However, these direct mortalities appear to be low. For example, recent estimates of mortality during passage through collection and bypass facilities on the Snake River dams for all species combined has been less than 1 percent at each facility. Rates could be higher or lower for individual years or species (Spurgeon et al., 1997; Hurson et al., 1999). One recent study at Little Goose Dam found mortalities during bypass of steelhead to be much higher, at about 5 percent. This value, however, could have included mortality from predation in the tailrace at the outfall site (Muir et al., 1998).

Recent PIT tag studies have suggested that the higher numbers of bypass systems that fish pass through, the lower their overall survival as a group (Technical Appendix A, Anadromous Fish). Currently, mortality of juvenile fish is usually about 1 percent at each Snake River dam, and up to 3 percent at each of the lower river facilities (Appendix A of Marmorek and Peters, 1998a). Recent values are presented by Hurson et al., 1999. Mortality has ranged from about 1 to 5 percent and 2 to 7 percent for yearling chinook salmon and steelhead at collection channels at Snake River dams (Muir et al., 1995, 1996, 1998). Direct mortality of transported fish is estimated to be about 2 percent (Marmorek and Peters, 1998a). As discussed under Section 5.4.1.5, Model Analysis of

All Alternatives, there is disagreement on the level of any latent mortality (i.e., mortality that could occur after release below Bonneville Dam) resulting from fish being transported (see Transportation). It is likely that under Alternative 1—Existing Conditions, direct mortality from collection and transport would remain relatively low. However, these mortalities could decrease as systems continue to be improved.

The other major source of mortality of juvenile fish at dams is through turbines or spillways. Turbine mortality may result from fish being ground in the narrow opening between turbine blades and the hub or walls, and then being directly struck by the turbine blade; from rapid changes in hydraulic pressure; from shear forces; or from cavitation (Wittinger et al., 1995). Overall, total mortality is affected by the proportion of fish passing through turbines and the efficiency of turbine operations. Slightly high mortality may occur when turbine operation is below or above peak efficiency. However, the 1995 and 1998 Biological Opinions (NMFS, 1995; NMFS, 1998) require turbines to operate within 1 percent of peak efficiency. Current operation is nearly always within 1 percent of peak efficiency. Estimates of turbine passage mortality vary over a wide range of current and historic conditions from 2 to 32 percent (Mathur et al., 1996; Ledgerwood et al., 1990; Weber, 1954; Long et al., 1968; Iwamoto and Williams, 1993; Muir et al., 1996 and 1998; Iwamoto et al., 1994; Schoeneman et al., 1961; Raymond and Sims, 1980; Gilbreath et al., 1993; Normandeau Associates Inc. et al., 1997). Some of these estimates of turbine passage mortality (e.g., 32 percent) include secondary mortality as a result of additional fish loss from such factors like predation between the time fish pass through the turbine and are later collected.

In 1996, the PATH Hydro Work Group concluded that turbine survival of spring/summer chinook salmon under current conditions is ≥ 90 percent and adopted a value of 90 percent survival at all facilities for modeling (Marmorek and Peters, 1998a). Most of the more recent turbine survival estimates have been higher. For example, at Lower Granite and Little Goose dams, estimates range from 92 to 93 percent, with similar values observed at various Columbia River dams (Normandeau Associates et al., 1996; Normandeau Associates and Skaiski, 1997; RMC et al., 1994; RMC and Skalski, 1994a and b; NMFS, 1999b). Some, however, have remained lower, such as at Lower Monumental where yearling chinook salmon have a survival rate of about 87 percent (NMFS, 1999b).

Direct mortality due to passage through a spillway results primarily from abrasion, but juveniles could die later through indirect means such as descaling, stress, predation, or reduced viability due to dissolved gas supersaturation. Accurate data on delayed mortality from this passage route are not available, although limited data suggest it is likely low and likely related to some degree to low residence time in the tailwaters (Muir et al., 1999). Ten of 13 juvenile passage studies conducted prior to 1995 found low mortality rates of 0 to 2.2 percent (most studies involved steelhead and yearling chinook salmon) for spillway passage at each dam (ISG, 1996; Marmorek and Peters, 1998a; NMFS, 1999b). However, three studies have indicated mortality can be as high as 4 to 27.5 percent (Long, 1968; Marmorek and Peters, 1998a). PATH considers these higher mortality values to be suspect (Marmorek and Peters, 1998a). Of six recent studies at Snake River dams, all but one had spill survival greater than 97 percent (NMFS, 1999b). If spill volume is very high, survival could be negatively affected at some projects as indicated by results at The Dalles Dam. Dawley et al. (1998) found

survival of only 76 to 92 percent at spill of 64 percent, but survival of 92 to 96 percent for spill of 30 percent. However, preliminary 1999 results found survival similar at both 64 and 30 percent spill, with all tests greater than 93 percent survival (NMFS, 1999b). The addition of spillway flow deflectors has been found to decrease mortality in some studies to near 3 percent (Muir et al., 1995 and 1998). Current estimates for modeling have generally used a direct mortality estimate due to passage over a spillway as 2 percent for all species (Marmorek and Peters, 1998a). Spillway passage direct mortality rates (about 2 percent) would likely remain within the range of those considered for models for Alternative 1—Existing Conditions (see Section 5.4.1.5, Model Analysis of All Alternatives). However, direct or indirect mortality associated with alterations of spill in the future (e.g., possible increased spill for passage and additional spillway flow deflectors) could alter mortality of fish passing through spillways.

The overall measure of the effectiveness of spill as a juvenile fish bypass method lies in the effect on system survival, not survival at each dam. Although fish passed through the spillway may survive dam passage at 98 percent, they continue their migration in the next reservoir at about 96 percent survival. Then, they may pass through another spillway at 96 percent survival into another reservoir at 94 percent survival. If they pass eight dams, their system survival is 61 percent. However, if they are collected and transported at the first dam, their system survival is about 98 percent.

If significant delayed mortality due to transport is assumed (as assumed by PATH), overall survival is less than 61 percent (19 to 39 percent in the PATH 1998 report). If it is assumed that delayed mortality due to transport is not significant (as indicated by NMFS), then overall transport survival is 79 to 98 percent, which is considered higher than the 61 percent in-river survival.

Transportation

The collection of juvenile salmonids and their transport downstream by trucks or barges for release below Bonneville Dam has been an integral part of the FCRPS since the 1970s. One of the main goals of transporting fish is to avoid mortality from passage through dams and reservoirs at projects downstream if they remain in-river. Since 1976, at least one million fish have been transported annually from the Snake River to below Bonneville Dam, with significant numbers being transported beginning in 1981 (Ward et al., 1997). For example, in 1999, about 16 million fish were collected and transported from the Snake River for release below Bonneville Dam. Currently, Snake River spring migrating fish, primarily spring and summer chinook salmon yearlings and steelhead, are collected at Lower Granite, Little Goose, and Lower Monumental dams. Summer migrants, primarily underyearling fall and summer chinook salmon (Columbia River only), are collected at these same dams plus McNary Dam. Research on the effect of transporting fish on their survival began in 1968 and continued through 1989, with recent studies occurring in 1995, 1996, 1998, and 1999.

Concerns about the effectiveness of transportation compared to other forms of passage (e.g., through turbines, over spillways) emerged in the 1990s and have not been resolved to date (NMFS, 1999c). Studies related to this issue have been conducted since the late 1960s (Ebel, 1970; Ebel et al., 1971-74; Ebel, 1974; Park and Ebel, 1975; Park et al.,

1976-86; Park, 1980; Park and Athearn, 1985; Park, 1993; Matthews et al., 1985-92; Matthews, 1999; Achord et al., 1992; Harmon et al., 1989-96; Marsh et al., 1996; Marsh et al., 1997a and b). Direct mortality during transport has generally been determined to be low, typically considered to be on average less than 2 percent, so emphasis has been placed on examining other areas of effects of transport on fish survival (NMFS, 1999c). The issue has been evaluated primarily by examining the ratio of returns of transported fish to those that remained in-river (i.e., not transported). The results of these experiments have been referred to in several ways, but have most recently been evaluated using the term transport to in-river ratio (TIR). The TIR is a ratio of the number of adults returning to a given location from a transport group of marked juveniles, to the number of adults returning to the same location from the group of marked juveniles released to migrate downstream in-river. If the TIR is greater than 1, it indicates that the test showed greater overall survival for transported fish than for those not transported.

Over 25 years of experimental results for spring/summer chinook salmon and steelhead have indicated that the vast majority of these studies resulted in TIRs greater than 1, with most ranging from 2.5 to 3 (Corps et al., 1999). For example, spring/summer chinook salmon had TIRs of 1.6 and 2.3 (Ward et al., 1997) and steelhead had similar TIRs of 2.0 and 2.1 in 1986 and 1989, respectively. The first studies conducted after 1989 were in 1995. Although the 1995 results are not complete, the initial TIR values for Snake River spring/summer chinook salmon are 2.0 and 2.1 for hatchery and wild fish, respectively. The TIR results for 1996 are incomplete but values are similar—1.4 and 2.7 for Snake River hatchery and wild spring/summer chinook salmon. Jack salmon returns for the 1998 study show similar trends (NMFS, 1999c). Data are not available for Snake River subyearling chinook salmon transported from any lower Snake River dam (mostly due to lack of sample fish to tag), but studies on the Columbia River from McNary Dam have subyearlings TIR ranging from 1.8 to 8. No data are available for sockeye salmon from the Snake River, and results from studies involving the Columbia River sockeye salmon collected and released at Priest Rapids Dam are not clear because the TIR was less than 1 for studies conducted in 1984 and 1986. Because of the differences in conditions and methods at Priest Rapids, these studies may not be representative of Corps dams (Chapman et al., 1997). However, later studies showed increased survival from transport (Carlson and Matthews, 1992; Mundy, 1994).

There have been questions about the methods used in many of the studies that evaluate TIR and the meaning of the results relative to wild fish returning to their natal streams (Ward et al., 1997; Olney et al., 1992). One of the main concerns is that the in-river marked fish are affected by the methods used to mark and release them and therefore their returns do not truly represent the differences between transported and in-river fish that are not marked. Some of the earlier studies used primarily trucks for transport of both transported and in-river fish (some in-river fish were transported past more than one dam before being released back to the river), so these results could have biased survival results (Ward et al., 1997). Another concern is that returns to dams (primary counting areas for returning fish) were not truly representative of survival to spawning ground, which the studies were not designed to measure because accurate counts of marked fish on the spawning grounds is difficult (e.g., adipose-clipped fins would show up, but all they would show is that the fish were marked, not which group they were in).

The data from years 1986, 1989, 1995, and 1996 appear to be closer to meeting the assumptions desired for a true measure of the overall transport survival. While studies in these years were not intended to measure survival to spawning grounds (from 1986 and 1989), collections of returning tagged fish in spawning grounds did not indicate as great a benefit to transportation survival (i.e., the TIR decreased compared to counts of comparisons made at dams) overall for wild fish survival (Olney et al., 1992). However, the total number of tagged fish found in these spawning areas was low, making interpretation of these results somewhat questionable.

Because of concerns that the controls used in the analysis were not true controls (Mundy, 1994; Ward et al. 1997), another method of evaluation of the effects of transport was also used with fish marked with PIT tags beginning in 1995 (NMFS, 1999c). From these studies, NMFS found that about twice as many fish that were transported returned as adults than did those released to the river. These results were similar to many of the earlier studies. However, the route fish took in passing through the system affected the relative survival; some tag groups that passed untransported had greater survival than some transported fish.

As discussed in Section 5.4.1.5, Model Analysis of All Alternatives, there is some concern that additional mortality from an undetermined cause occurs to fish that are transported; this is known as "differential delayed transport mortality." The ratio of survival to adult return of transported fish below Bonneville Dam to the estimated survival to adult return of in-river migrant fish to below Bonneville Dam is an index of the relative post Bonneville Dam additional mortality of transported fish. This value is referred to as a D-value in the NMFS analysis and is described in more detail in Section 5.4.1.5 and in Technical Appendix A, Anadromous Fish. This D-value is not a measured value. Instead, it is the difference between the estimate of survival for fish migrating in-river and for those that are transported.

A D-value of 1 would indicate no differential delayed mortality of transported fish, while values less than 1 suggest additional mortality occurs to transported fish compared to in-river migrants. All models to date have indicated that the average D-value is less than 1, which indicates that some additional delayed transport mortality is occurring. Recent information is not clear on whether barging has any initial effects on lower river (below Bonneville Dam) mortality relative to fish that are not barged (in-river fish). Recent tracking of radio-tagged spring chinook salmon has found no significant difference in overall survival or susceptibility to bird predation between barged and in-river fish in the reach below Bonneville Dam to the start of the estuary (Schreck and Stahl, 1999). Radio-tagged barged fish had survival ranging from 74 to 100 percent, while radio-tagged in-river fish had survivals ranging from 65 to 96 percent during spring 1998. Average bird predation, based on recovery of all radio tags, was 17 percent. But some PIT tag recovery information, used to indicate Caspian tern predation, has suggested that barged spring chinook salmon may have been more susceptible and barged steelhead less susceptible to bird predation during 1998. In contrast, information from the same study in 1997 found no difference in susceptibility to predation of barged fish of either species (Collis et al., 1999).

Possible causes of additional mortality resulting from transport have been postulated to be the result of natural mortality or increased stress or disease. Delayed natural mortality

may occur because fish transported are protected from many natural conditions (e.g., predation, ability to find food over an extended period, proper migrating ability) that would have resulted in their death during migration had they not been in a barge. Surviving in-river fish have already undergone the "natural" mortality process; many of the fish less well-suited to survival in the wild would have died before passing Bonneville Dam. The result is that the barged fish population would contain a higher portion of fish less well-suited to survive in the wild. The effect would be that some of the barged fish would suffer a higher rate of mortality at some point after they are released from the barge than those that migrated in-river. Stressful environments for extended periods decrease survival. The process of collection and loading fish increases stress for some stocks, although studies have documented that stress is reduced by the time fish are released from the barge, except possibly during peak migration (Schreck et al., 1998; Schreck and Stahl, 1999). Disease is thought to possibly increase during barging because fish are confined to a small area in close proximity to other fish during transport. Some studies have found spring chinook salmon have lower resistance to general infections under extended crowded conditions (Schreck and Congleton, 1994). However, Elliott and Pashco (1993 and 1994) have demonstrated that bacterial kidney disease (BKD) organisms are prevalent in-river as well as in the collection and transportation system. The majority of fish, both hatchery and wild, are infected by the time they reach the first collection and transport facilities at Lower Granite Dam. NMFS (1999d) concluded that while BKD is highly prevalent in Snake River smolts, the effect of fish transport on disease-caused mortality of these fish remains unknown.

In comparison to collection and transportation, it is important to emphasize that in-river migration is also stressful for fish. Passing eight dams and reservoirs, which could include migration through spillways or turbines, can cause stress. Potential exposures of fish to elevated dissolved gas concentrations also subjects fish to stress, especially during periods of high system-wide spill.

Other issues relative to transport include whether transport affects adult homing, whether truck transport is as effective as barges, and whether survival of trucked fish is higher than in-river fish survival. NMFS (1999c) indicates there has been no documentation of straying of transported Snake River fish to other streams at rates that deviate from natural straying rates. Limited effects of trucking vs. barging have been conducted. Of five paired tests, only one showed significantly lower survival of trucked fish than barged fish (NMFS, 1999c). Release procedures have changed from earlier studies to try to reduce the effects of release locations on survival. Recent data using the new release procedures indicate that trucked fish survive at significantly higher rates than those traveling in-river (Matthews, 1999).

Under Alternative 1—Existing Conditions, fish transportation would continue, with all fish collected at the three dams on the Snake River and for summer migrants only at McNary Dam based on the 1998 Biological Opinion (NMFS, 1998). Spill would be used, to the extent possible, under the "spread the risk" policy (see Section 2) to bypass fish at all dams where fish are not either collected and transported or passed through turbines. This would mean about 50 to 60 percent of the spring/summer chinook salmon and steelhead, possibly sockeye salmon, and a lesser portion of fall chinook salmon, would be transported around dams and released below Bonneville Dam. This would

continue until sufficient data are gathered from tagging studies to determine if the transport program should be altered.

Dissolved Gas Supersaturation

Gas bubble disease or trauma can result when fish are exposed to dissolved gas that is greater than saturation. Gas bubble disease has been a well-documented source of past mortality in the Columbia River System (Ebel et al., 1975; Weitkamp and Katz, 1980). Factors that contribute to this disease include the degree of supersaturation, duration of exposure, water temperature, physical condition of the fish, depth of travel of the fish, and life stage (Ebel and Raymond, 1976; Wietkamp and Katz, 1980; Filder and Miller, 1993). Spillway flow deflectors (see Section 2) constructed at most dams since the late 1970s have reduced the extreme production of reach-wide gas supersaturation that caused significant mortality in the 1970s. These factors make it difficult to determine what percent of total dissolved gas (TDG) is considered safe for aquatic organisms in the Snake and Columbia rivers.

Most studies on dissolved gas supersaturation have concentrated on direct effects, which have included major changes in the effects of physiological function, physical damage from internal bubble formation, and death. Also, there is evidence of secondary effects of gas bubble disease. Frequently, gas bubble disease has been noted as increasing susceptibility to factors such as bacterial, viral, and fungal infections (Meekin and Turner, 1974; Nebeker et al., 1976; Weitkamp and Katz, 1980; and White et al., 1991). It can also increase susceptibility to predation (White et al., 1991). Information summarized from several studies has documented adverse effects, including either acute or chronic mechanisms of mortality beginning as low as 110 percent saturation (Filder and Miller, 1993; Weitkamp and Katz, 1980). Additionally, some studies suggest gas saturation may affect other aquatic organisms, including invertebrates that could be food for salmonids. Bioassay studies of aquatic mayflies below a hydroelectric project in Montana found that gas levels as low as 114 to 118 percent could cause adverse effects to these organisms and concluded that at least these mayfly species were susceptible to negative affects from operation of the hydroelectric project (Brammer, 1991). However, samples of invertebrates residing below Bonneville Dam did not detect visible signs of effects to invertebrates from dissolved gas concentrations within or somewhat in excess of this range (Toner et al., 1995). However, no bioassays were conducted on organisms in this region.

Interpretation of which dissolved gas saturations cause significant adverse effects to migrating salmonids differs by source (BPA et al., 1995). The current maximum EPA and Washington State water quality standard for the Columbia-Snake River System is 110 percent. However, under current operations, the state establishes exemptions that allow operations to attempt to achieve 115 percent in forebays and 120 percent in tailraces, under specific operating conditions. If natural runoff is high, TDG would exceed the 120 percent concentration, often being greater than 130 percent, even with current gas abatement methods.

There is a dissolved gas monitoring program which includes monitoring and examination of migrating fish externally for signs of gas bubble disease (Fish Passage Center [FPC], 1999). Generally, external signs of gas bubble disease have been low when total

dissolved gas was less than 115 percent, and observed symptoms only approached 10 percent occurrence when system-wide TDG in-river was 125 percent. NMFS (1999b) concluded that, even during periods of involuntary spill in recent years, impacts to juvenile salmon and steelhead appeared to be minor except when TDG exceeded 120 percent. These types of results differ from laboratory results and tests, including caged fish in the Columbia River (Ebel et al., 1975; Toner et al.; and Schrank et al., 1966, 1997, 1998). These studies suggest much more severe reactions at these higher saturation amounts (i.e., 115 to 120 percent). The meaning of the differences is open to interpretation. Fish in the wild could be able to compensate by swimming at depth, or they could only encounter the higher TDG for a shorter time. It is also argued that the lower observed incidence could be from increased mortality, which eliminates fish affected by the gas supersaturation from the sample. Some additional field data attempt to contradict this theory (FPC, 1999), but the question is not answered with available data. Fish that are transported in barges are not subjected to the elevated gas levels like those that pass in-river because each barge is equipped with de-gasifiers that eliminate supersaturated conditions in the barge water.

The cause-and-effect relationship of gas bubble disease symptoms is not easily demonstrated (Williams et al., 1997). Bubbles can grow internally in a fish's body, disrupting neurological, cardiovascular, respiratory, osmoregulation, and other physiological functions (Stroud et al., 1975; Weitkamp and Katz, 1980). At some TDG concentrations, external symptoms of gas bubble disease may not be apparent; therefore, assessing effects to fish populations by external examination could be unreliable and would not reflect behavioral effects. A detailed discussion of the possible effect of gas supersaturation on Columbia River salmon is presented in System Operation Review Appendix C (BPA et al., 1995) and additional discussion is presented in Technical Appendix C, Water Quality. However, based on the several years of recent monitoring in the Columbia and Snake rivers (Maule et al., 1997; Backman et al., 1997), current thinking by NMFS (1998) is that if TDG remain in the 115 percent to 120 percent range, migrating juvenile salmonids would not be threatened. Under Alternative 1—Existing Conditions, current conditions would likely be maintained with periodic elevations of dissolved gas concentrations that could cause adverse effects to fish. There are, however, continuing modifications to facilities (e.g., full compliment of spillway flow deflectors at Ice Harbor in 1998-99) being constructed to reduce these effects. The Corps is evaluating construction of end bay deflectors at Lower Monumental, Little Goose, McNary, and Bonneville dams. The Corps will also evaluate potential modifications to existing spillway flow deflectors at some dams to improve their performance.

Predation

One of the major causes of fish mortality during migration is predation by resident fish (Poe and Rieman, 1988; Rieman et al., 1991). More recently, predation by birds has also become a problem (Petersen et al., 1999; Roby et al., 1998; NMFS, 1999d; Collis et al., 1999). Predation by marine mammals on juvenile salmonids occurs in the marine environment and possibly in the lower river, but the overall impact of this predation is unknown (NMFS 1999d). Predation is considered by some to cause mortality equal to or greater than that caused by passage at dams (Rieman et al., 1991). The primary predator

in much of the Columbia River System is northern pikeminnow (Beamesderfer et al., 1990), but in Snake River reservoirs it appears to be smallmouth bass (Curet, 1993; Bennett et al., 1997; Petersen et al., 1999; NMFS, 1999d). Predation within the Columbia and Snake rivers occurs throughout the reservoirs, but is often concentrated just below and above dams (Poe and Rieman, 1988; Poe et al., 1991). Additionally, many non-native fish including bass, crappie, yellow perch, walleye, and catfish also contribute to predation of migrating juvenile salmon and steelhead (NMFS 1999d). The current management of these stocks as "game" fish may contribute to predation on the listed stocks. The Northwest Power Planning Council's Framework Process (see Section 3.0) is considering alternatives to manage these non-native predators for the benefit of the listed stocks.

Estimates of losses due to predation are quite variable by species and location. Spring juvenile salmonid migrants (typically yearling smolts) appear to suffer relatively low mortality in the Snake River System. At Lower Granite, estimates were less than 1 percent mortality loss from northern pikeminnow (Chandler, 1993). Estimates of total reservoir loss, exclusive of dam passage losses, through the entire lower Snake River reach for spring migrants (spring/summer Chinook salmon and steelhead) was only about 1 percent (Petersen et al., 1999). In the Columbia River, mortality rates due to predation could be higher for spring migrants. Rieman et al., (1991) estimated a mortality rate of about 11 percent in John Day Reservoir for spring migrants. However, summer migrants at John Day Dam had much higher mortality rates from resident fish, ranging up to an estimated 61 percent (Rieman et al., 1991). Total estimated loss of smolts in the mainstem Columbia and Snake rivers to just northern pikeminnow, prior to the current predator removal program was estimated to be about 8 percent of all smolts (NMFS, 1999d). Average estimates of losses due to predation for the entire impounded Snake River reach were modeled to be about 59 percent for summer migrating fall chinook salmon (Petersen et al., 1999).

Piscivorous birds congregate near hydroelectric projects along the river and in the estuary and lower river near man-made structures and islands and consume large numbers of migrating smolts (Roby et al., 1998; Collis et al., 1999; NMFS, 1999d). Recent estimates of consumption in 1997 and 1998 are that 10 to 30 percent (best estimate—17 percent) of all potential smolts that otherwise would be found below Bonneville Dam were consumed by birds (Collis et al., 1999). These estimates indicate predation occurred by gulls, double-crested cormorants, but primarily by Caspian terns. It was estimated that in 1997, 6 to 25 million smolts—or about 6 to 25 percent of all smolts arriving at the Columbia River estuary—were consumed by Caspian terns alone (Roby et al., 1998). It was estimated that in 1998, Caspian terns consumed 7 to 15 million smolts, or 8 to 16 percent of those arriving at the estuary (Collis et al., 1999). Similar bird predation rates likely occurred again in 1999, although no estimates are available (*Columbia Basin Bulletin*, July 9, 1999). Action was taken in 1999 to attempt to move 90 percent of the existing terns from Rice Island to an island further downstream in the Columbia River where predation on juvenile salmonids would be reduced. However, the results indicate that few terns moved, with 7,300 nests developed in 1999 at Rice Island and only about 10 percent of that number at a downstream island (*Columbia Basin Bulletin*, June 18, 1999).

Predation by birds is influenced by the availability of habitat, species, possibly by fish conditions, and maturity. The presence of a newly formed island in the lower river has

helped increase predation by birds. The presence of dams also contributes by allowing birds to congregate and prey on possibly disoriented fish after they pass through the dams. In the lower river, the amount of time fish spent in-river before entering the ocean, depth distribution, and schooling behavior may influence predation. Generally, it was observed that a greater portion of juvenile steelhead were consumed by Caspian terns, possibly because the juveniles were near the surface. The effects of bird predation on fish transported and released below Bonneville Dam is not clear. Schreck and Stahl (1999) found no difference in predation of spring chinook salmon between fish released from barges or those traveling in-river. Collis et al. (1999) found in 1998 that spring chinook salmon and steelhead that were transported were slightly more and slightly less, respectively, susceptible to predation by birds than were in-river fish during 1998. However, there was no significant difference between these groups in 1997. It is speculated that less mature fish, which may include transported spring chinook salmon, may tend to stay in the fresh water longer before entering the ocean, making them more susceptible to bird predation.

Predation by marine mammals, some of which are present in the Columbia River mouth area, also occurs (NMFS 1999d). Harbor seals are the most abundant mammal in the lower Columbia at about 2,000 individuals, while California sea lions number about 100 to 200. Juvenile salmon were reported to constitute 19 percent of the diet of harbor seals in the lower Columbia. Juvenile salmon account for 3.6 percent of the diet of California sea lions. Whether the portion of food in their diet is reflective of consumption in the Columbia River mouth is unknown, because they may forage over a wide range, including in areas outside of the Columbia River mouth. As a result, overall estimates of the loss of total juveniles to marine mammals in the lower Columbia River are not available.

Mortality rates due to predation are affected by many factors including current velocity, turbidity, cover, location, predator abundance, prey abundance, and water temperature. Of these factors, temperature is a major controlling factor for predation by fish (Beamesderfer et al., 1990; Petersen et al., 1999). Cooler temperatures tend to reduce predation rates, because predator consumption rates are less (Beamesderfer et al., 1990; Petersen et al., 1999). As temperatures warm, activity and metabolic rate of predators increase, making them more active predators and increasing their need for food.

The source water for flow augmentation could affect predation rates in the Snake River system. Muir, et al. (1998) found that survival of subyearling chinook salmon was lower during a year when water used for flow augmentation was released from the warmer Brownlee Reservoir than from cooler Dworshak Reservoir. Cool water from Dworshak Reservoir releases could influence water temperature in the Snake River, which could affect survival by reducing predation rates. However, cooler water releases from Dworshak Reservoir delay emergence and migration timing of Clearwater River fish, which could, in turn, increase mortality rates of those fish as they enter the warmer waters in the Columbia-Snake River System later in the year (Connor et al., 1997). Higher water velocities from flow augmentation could also affect survival rates of juvenile fish migrating through reservoirs by reducing the predation rate. However, many factors affect both migration rate and predation (e.g., temperature, turbidity, and fish size) which greatly influence the overall effectiveness of increased flow on survival from predation. Alternative 1—Existing Conditions would maintain the level of

predation currently occurring in the system. However, the source of water for augmented flows, either from Dworshak or Brownlee reservoirs, would influence predation rate and survival of primarily juvenile fall chinook salmon and some sockeye salmon in the Snake River System. Augmentation flow releases from Dworshak and Brownlee reservoirs would be balanced to some degree to help optimize temperature in the Snake River during the summer juvenile fall chinook salmon migration period.

Rearing/Migratory Habitat

Rearing habitat is important during migration for all stocks, but especially for subyearling chinook salmon, which rely more heavily on mainstem habitat for rearing than other Snake River salmonid stocks. The quality and use of the habitat is affected by species, depth, velocity, substrate, benthic and pelagic food supply, temperature, and turbidity. Backwater and slough habitat is used in the lower Columbia during spring and summer migration (Zimmerman and Rasmussen, 1981; Parente and Smith, 1981). Nearshore areas are primary rearing areas for subyearling chinook salmon in river reach areas of the Columbia River (Venditti et al., 1997b). In the middle Columbia River, they use shallow-water, low-velocity areas (Dauble et al., 1999).

Subyearling fall chinook salmon in Snake River reservoirs prefer low-velocity sandy habitat less than 20 feet deep (Bennett, et al., 1983; Curet, 1993). They rear in the Snake River and Lower Granite Reservoir for about 75 to 112 days before they migrate downstream (Curet, 1993). In both the Columbia and Snake rivers there is movement offshore before migration begins (Curet, 1993; Venditti et al., 1997).

The rearing period of yearling chinook salmon, steelhead, and probably sockeye salmon is likely no more than a few days in any reservoir. These fish are less oriented to the shallow shoreline, although they probably rely on food sources produced in these areas during their short residence time in the reservoirs.

Under Alternative 1—Existing Conditions, food supply and rearing habitat would remain as they are now, although the source of water for flow augmentation (i.e., Dworshak Reservoir, Brownlee Reservoir, or other) can affect water temperature, which can alter habitat in some areas. Food sources for subyearling fall chinook salmon could already be in short supply in the lower Snake River reservoirs (Curet, 1993). This likely would remain the same under Alternative 1—Existing Conditions.

Altered water temperatures in the early summer could benefit some Snake River subyearling fall chinook salmon. Optimum temperature for salmonids is typically less than 59°F. Temperatures exceed this during much of the fall chinook salmon rearing and migration periods in the reservoirs. Historically, prior to reservoir development, temperatures also likely exceeded optimum values within this region (Technical Appendix C, Water Quality). The release of cool water from Dworshak Reservoir would benefit rearing conditions in the downstream reservoirs, while increased release from Brownlee Reservoir would increase temperature, likely reducing habitat quality during the summer period.

Under Alternative 1—Existing Conditions, rearing habitat could remain similar to the 1996 to 1998 period. During this period, habitat condition varied, but included some improved rearing habitat over earlier years. During 1996, Dworshak flow releases did

not occur until August, which would have little benefit to rearing habitat conditions. However, in 1997 and 1998 flow releases were earlier, which contributed to cooling the reservoirs (usually less than 70°F) during a larger portion of juvenile fall chinook salmon rearing and passage period, likely improving habitat quality. But the use of Dworshak Reservoir water has conflicting interests (e.g., maintaining reservoir levels for recreation, releasing water earlier for cooling rearing habitat flow augmentation for juvenile passage, or releasing water later to cool water for adult passage releases), thus the benefits to rearing habitat may vary from year to year depending on what managers decide for a given year.

Effects on Adult Anadromous Salmon and Steelhead

Survival of adult salmon and steelhead is also affected by passage over dams and through reservoirs as they move upstream to their spawning grounds. The stocks of the Snake River, with few exceptions, need to pass all four lower Columbia and four lower Snake River dams and reservoirs before returning to the natal spawning stream of origin. Conditions in the reservoirs, including water quality and flow conditions, affect migration rate and overall survival. Structures and flow patterns at dams also affect the ability of these fish to find their way successfully upstream without suffering injury or delay in migration.

Upstream Passage

Upstream migration of fish through dams can be related to the ability of fish to find and ascend the ladders and not fall back or be swept downstream through the spillway, through the turbine, or other routes such as navigation locks. Conditions in the reservoirs can affect the ability of adult fish to successfully migrate upstream. Reservoirs also affect the amount of available spawning area in the mainstem reaches of the Columbia and Snake rivers because lower velocity areas created by the reservoirs are not used. Successful migration through reservoirs is related to water quality, particularly water temperature and dissolved gas, which directly and indirectly affect survival.

Some adult fish die during upstream migration. The causes of the mortality are not completely known, but likely include natural and human-caused factors. The sources of mortality could include delay in migration, fallback through turbines, delayed mortality from marine mammal injuries, gillnet interactions, and disease (NMFS, 1995; NMFS, 1999b). The loss of adult fish as they move upstream varies somewhat by species. Estimates of loss of adult fish passing all eight dams and reservoirs from Bonneville Dam to Lower Granite Dam, independent of fish harvested in-river and others that migrate into intervening tributaries or the upper Columbia, vary by species. Recent estimates based primarily on radio tagging studies suggest that 24, 50, 21, and 22 percent of Snake River spring/summer chinook salmon, fall chinook salmon, steelhead, and sockeye salmon, respectively, are lost independent of harvest during upstream migration past these eight hydropower facilities (Technical Appendix A, Anadromous Fish).

Delays in migration traditionally may have occurred at natural barriers within the Columbia River System (e.g., Celilo Falls) but now may occur at dams. This can result in loss of food reserves in tissues that could contribute to mortality. The amount of spill is one factor that affects upstream migration rates at dams. For example, delay at one

Snake River dam was low (about 1 day) when spill was less than 25 kcfs, but up to 7 days when spill was from 25 to 125 kcfs (Turner et al., 1983). Higher spills (greater than 60 kcfs) occasionally make fish ladder entrances difficult to find (Turner et al., 1983). During 1993, the median delay per lower Snake River dam was from 0.6 to 1.2 days during periods of no spill to spill of 40 to 80 kcfs (Bjornn et al., 1994). Voluntary spill used to pass downstream migrants past dams in the spring does not appear to cause delays in upstream passage at dams for adult fish (Bjornn et al., 1998).

Higher spills can also influence fallback (adult fish that successfully pass upstream of a dam but are either swept or swim through the spillway, turbines, or navigation locks to below the dam). Bjornn and Peery (1992) found fallback was less than 10 percent when spill was low, but increased to 40 percent during high spill for spring chinook salmon. The occurrence of fallback remains low, about 3 to 5 percent during low flow periods for salmon (Bjornn et al., 1992 and 1993). Fallback is higher for steelhead. Bjornn et al. (1998) found that fish that fell back one or more times were less likely to find their way back upstream to hatcheries or spawning areas. While some fish are lost in this manner, most re-ascend ladders and continue upstream. However, some fish that fall back are strays that have wandered into the wrong area and need to move back downstream to find their natal location. Bjornn et al. (1998) also found that the incidence of headburn was more common on individuals that fell back over dams multiple times. Maximum fallback mortality rates of fall chinook salmon have been 14 to 26 percent in 1993 and 1994 (NMFS, 1999b). The high rate is likely from a high straying rate of fish from other areas (Mendel and Milks, 1997). But survival to spawning grounds for those fish that ultimately stayed above Lower Granite was likely high, possibly 95 percent (Mendel and Milks, 1997).

While dam passage is slower than through the reservoirs, it is unlikely that overall passage time—at least on the Snake River—has changed since the four lower Snake River dams were installed (NMFS, 1999b). Bjornn et al. (1998) reported that the overall time for radio-tagged spring/summer chinook salmon to migrate through the lower Snake River (about 6.4 days) was comparable to that of pre-dam conditions. Upstream migrants were slowed at dams, but migration through reservoirs was at a faster rate than through free-flowing rivers. Overall survival of spring/summer chinook salmon in 1990 from passage of Ice Harbor to the spawning grounds ranged from about 54 to 77 percent, which is comparable to 46 to 55 percent from 1960 to 1980. The limited data of the period before dams were constructed in this reach suggest that survival through this reach may not have changed or may be higher than before the lower Snake River dams were constructed (NMFS 1999b).

In general, the rate of migration through lower Snake River reservoirs is faster than through comparable rivers (Bjornn et al., 1992, 1993, and 1998). Some reduction in migration rates has been observed for steelhead during periods of minimal flow in reservoirs, but this could have been related to high temperature (Bjornn and Peery, 1992). Results from other studies during minimal flow periods with lower water temperatures showed no observed delays of steelhead.

Temperature

High water temperature can negatively affect migration of adult salmon and steelhead. Water temperatures in excess of 68 to 70°F occur frequently in the Snake River, particularly during adult fall chinook salmon and steelhead upstream migrations. This could impede upstream migration or increase mortalities (EPA and NMFS, 1971; Bjornn et al., 1997). Temperatures in excess of 68 to 70°F have occurred both prior to reservoir construction and since they were formed (Chapman et al., 1991). Prior to dam construction on the lower Snake River during the 1952 to 1956 period, daily temperatures in the Snake River below the confluence of the Clearwater exceeded 70°F over 5 percent of the time, and 65°F over 17 percent of the time (Technical Appendix F, Hydrology/Hydraulics and Sedimentation).

Since dams have been in place, the addition of cool water releases from Dworshak Dam in the summer has resulted in reduced periods of high temperature in the Snake River reservoirs below the Clearwater River. During the low flow year of 1994, when flow releases from Dworshak equaled about 50 percent or more of the flow in the Snake River, temperatures were reduced by about 11°F. However, when flow from Dworshak stopped, temperatures exceeded 70°F. In 1995 and 1997, when flows were higher, the relative effect of lower water temperature releases from Dworshak was reduced to about 5°F and 2 to 4°F during the moderate and high flow years, respectively. During these years, temperatures in the reservoirs rarely exceeded 70°F, partly due to Dworshak flow releases, but also due to total flow and air temperature conditions (Technical Appendix C, Water Quality). These cool water releases from Dworshak should benefit adult fall chinook salmon passage. However, temperatures exceeded 68°F in the Snake River upstream of Lower Granite pool during periods in July and August 1998 (Petersen et al. 1999).

Dworshak flow releases will vary from year to year depending on water availability and management direction. The main purpose of these releases has not been completely resolved among management groups with varied opinions about whether to release Dworshak water to just increase flow for juvenile passage or also release flows to reduce temperatures. Some modeled estimates of water temperature suggest that late summer temperatures in the reservoirs may not cool as rapidly as they did in-river in the past (Technical Appendix C, Water Quality). The exact effect of possible shifting of temperature period on fall chinook salmon is not clear, but could influence when spawning occurs and ultimately when juveniles emerge from the gravel relative to what occurred historically. Again, the Snake River fall chinook salmon stock that currently occupies the Snake River could vary from the original native stock in their outmigration behavior in timing in response to increasing water temperature (Waples et al., 1991).

Dissolved Gas Supersaturation

As with juvenile fish, excessive dissolved gas supersaturation can cause mortalities of adult salmon and steelhead. During periods of high flow in the 1965 to 1970 period (which was before dam modifications were in place to reduce gas levels from spill), it was estimated that from 6 to 60 percent of adult salmon died before spawning as a result of gas supersaturation (Weitkamp and Katz, 1980). During this period, dissolved gas levels most often noted as causing adverse effects were in excess of 120 percent. However, concentrations considered acceptable by Oregon's or Washington's water

quality standards are still less than 110 percent. But during some spring periods, these states have recently set a standard of 115 to 120 percent as acceptable depending on location and period (see Section 5.3, Water Quality).

Structures in place on dams (spillway flow deflectors) and flow management (upstream storage facilities and increased flow through turbines) have reduced the higher saturation of gas that occurred frequently in the past. As indicated earlier, state agencies have allowed waivers in water quality standards that allow TDG concentrations to increase to 115 or 120 percent, depending on specifics of timing and location. Still, involuntary spill (i.e., spill exceeding turbine capacity) has resulted in elevated saturation over 120 percent and over 130 percent during recent years. Even with these high TDG, signs of adverse effects have been low. For example, in 1997, a high flow year, only 0.1 percent of chinook salmon at Lower Granite Dam showed external physical signs of gas bubble disease. However, during June of that year, signs of gas bubble disease were more common in sockeye salmon and steelhead at Bonneville Dam. All of the mortality monitoring data show that gas bubble disease incidence and mortality are related to exposure duration and magnitude of TDG in a close-accumulation fashion (ISAB, 1998). Mortality occurs in the gills, not the fins and fish can die without any external bubble signs.

Based on observed external signs of gas bubble disease, concentrations of 115 percent to 120 percent do not appear to cause adverse effects to adults (NMFS, 1999b). These are the concentrations currently allowed under the annually granted water quality waivers. Based on current monitoring, it appears that adult spring/summer chinook salmon are not likely to be adversely affected by gas supersaturation even though they are present during periods of potentially high spill in the spring. High TDG could cause delayed stress, resulting in extra expenditure of energy reserved for spawning, an extra mortality effect. Due to this potential mechanism, bioenergetic and radio-tagged studies have been funded by the Corps for implementing in Fiscal Year 2000. Sockeye salmon and spring migrating steelhead could be more likely to have some adverse effects. Dissolved gas concentrations are unlikely to affect fall chinook salmon because they are in the river during periods of high spill at only Ice Harbor instead of all four lower Snake River dams (spill is 24 hours at Ice Harbor through August and subyearling outmigration peaks in July).

Spawning Habitat

Historically, much of the mainstem Columbia and Snake rivers contained areas of spawning habitat, primarily for fall chinook salmon (Fulton, 1968). Most of the historical fall chinook salmon spawning habitat was lost from dam construction upstream of the lower Snake River dams (mostly from Hells Canyon Dam upstream). The relatively small region of historical fall chinook salmon spawning habitat in the lower Snake River is currently inundated by the lower Snake River reservoirs. The actual historical use of this habitat by spawning fish is unknown. Historic river reconstruction of conditions during 1934 was done by BRD (1999) and Battelle-Pacific Northwest Laboratory (Hanrahan et al., 1999). Based on estimates of suitable physical habitat conditions (e.g., depth, velocity, substrate) developed through geographical information system (GIS) BRD estimated that 23 percent of the historical river channel had conditions considered usable for spawning. Most of the predicted spawning habitat was

below Ice Harbor Dam, and within Ice Harbor and Lower Monumental pool areas. The data also indicated that two deep runs (>50 feet deep) located just upriver from the Palouse River in the Lower Monumental reservoir and in Anchor Canyon in Ice Harbor reservoir could have provided coolwater holding habitat for upstream migrating adults, such as fall chinook salmon and steelhead, during warm periods. Some very limited fall chinook salmon spawning currently occurs in the tailrace areas below Lower Granite and Little Goose dams and there could be some potential spawning habitat below the other two dams in less than one percent of the reservoir area (Dauble et al., 1999). Continued operations under Alternative 1—Existing Conditions would allow for maintenance of the limited use of these areas for spawning.

Adult Summary

Overall, under Alternative 1—Existing Conditions, conditions would remain the same as they were in the recent past with some slight changes. The extent of spawning habitat for adult salmon and steelhead in areas upstream of the four lower Snake River reservoirs would remain the same. Continued efforts would occur at improving adult passage facilities at some of the dams. This should allow better conditions for upstream migration. Gas abatement methods would be improved including installation of spillway flow deflectors at Lower Monumental, Little Goose, McNary, and Bonneville dams to reduce the effects of spill on increasing TDGs. While not directly planned for the benefit of adult fish, some increased frequency or duration of cooler water releases from Dworshak in mid- to late summer could occur. This could benefit upstream migrating fall chinook salmon and steelhead by reducing delays in the Snake River reservoirs, thereby reducing the use of reserve energy stored in fish tissues. This could result in the increased survival of adults migrating to spawning areas.

Effects on Other Columbia River Anadromous Salmonids Including Federally Listed and Candidate Species

Many stocks of anadromous salmonids have recently been listed or proposed for listing under the ESA (see Section 4.5, Aquatic Resources). However, because current operations would remain the same under Alternative 1—Existing Conditions, there would be no change in the effects already occurring from the Lower Snake River Project for these non-Snake River basin stocks. The factors (e.g., temperature, transportation, and predation) discussed previously for Snake River stocks would apply as they relate to the relative location of each of these stocks. However, the direct effects of the hydrosystem within the Columbia River are not part of the currently evaluated actions.

Columbia River Stocks Above Bonneville Dam

Potentially affected stocks originate from two geographical areas: 1) Columbia River and tributaries (except the Snake River) above the McNary pool, and 2) Columbia River and its tributaries between Bonneville and McNary dams. These stocks primarily include steelhead, sockeye salmon, and chinook salmon. They also include three listed Evolutionary Significant Units (ESUs) involving chinook salmon and steelhead. Stocks originating above McNary Dam would be affected by passage both up and downstream through the lower four Columbia River dams in a similar manner to those discussed for

Snake River stocks that pass these dams. These include similar effects for juveniles from transportation, dam passage, predation, flow and water velocity, dissolved gas supersaturation, temperature, and rearing habitat. Upstream migrating adults would also encounter situations involving potential migration delay at dams, interproject loss of adults, increased exposure to elevated dissolved gas, and potential water temperature problems. Those stocks originating below McNary Dam would be similarly affected except they would not be affected by juvenile transport and would have fewer dams to pass.

The only factors that could directly affect the non-Snake River stocks under Alternative 1—Existing Conditions are related to potential changes in the flow regime or water quality in the Snake River. Under Alternative 1—Existing Conditions, no changes in either flow or water quality from the Snake River are anticipated. Therefore, effects on non-Snake River stocks would also remain unchanged from current conditions.

Columbia River Stocks Below Bonneville Dam

There are seven Federally listed, proposed, or candidate ESUs primarily originating in the lower Columbia River involving either chinook salmon, chum salmon, coho salmon, steelhead, or coastal cutthroat. There are fewer issues related to project effects for these stocks than there are for non-Snake River stocks originating above Bonneville because hydrosystem operations of the lower Snake River do not directly affect them. The major factors that could indirectly affect these stocks are quantity of flow and water quality (temperature, gas saturation). As with the non-Snake River stocks above Bonneville Dam, conditions for stocks originating below Bonneville Dam would not change as a result of Alternative 1—Existing Conditions.

Other Anadromous Stocks

American Shad

Populations of American shad undergo fluctuations from year to year, but have remained generally abundant in the Columbia-Snake River System for over a decade. The fluctuations could be somewhat dependent on flow and water temperature, as juveniles rear in the reservoirs prior to outmigrating in the fall. Future considered actions under Alternative 1—Existing Conditions (see Section 2) are not likely to cause changes that would affect the overall populations of American shad.

Pacific Lamprey

Future conditions under Alternative 1—Existing Conditions for Pacific lamprey are unclear, but may not result in significant changes in the overall decreasing trend in abundance. Most spawning and rearing of lamprey currently occurs in tributaries to the mainstem Columbia or Snake River, so project actions are not likely to affect rearing. However, there is concern that passage at dams could be having adverse effects on these stocks (Technical Appendix M, Fish and Wildlife Coordination Act Report). Pacific lamprey juveniles appear to migrate in deeper water and are often found entering turbines near the middle to bottom area (Long, 1968; Close, et al., 1995). The survival

rate of lamprey through turbines is unknown. Screening systems that are currently in place at most Snake River and Columbia River dams may be unable to divert many of these fish away from turbines because of their deeper orientation. However, lamprey have been occasionally impinged on these screens (Hammond, 1979). The planned installation of deeper STSs or ESBSs in the future under Alternative 1—Existing Conditions could improve passage over current conditions by diverting fish away from turbines.

The effects of flow or reservoir environments on survival or predation of Pacific lampreys as they migrate downstream are not known. However, their small size and poor swimming ability as juveniles suggest that migration downstream could be primarily correlated with water velocity (Kan, 1975). With higher velocities, migration (associated with increased flows during the spring) could result in shorter migration times.

5.4.1.2 Alternative 2—Maximum Transport of Juvenile Salmon

The effects under Alternative 2—Maximum Transport of Juvenile Salmon differ only slightly from Alternative 1—Existing Conditions. The major operational changes under Alternative 2—Maximum Transport of Juvenile Salmon that would affect survival of anadromous fish are an elimination of voluntary spill at Lower Monumental, Little Goose, and Lower Granite dams. Ice Harbor Dam does not have transport facilities, so spill would continue at this dam during the spring and summer juvenile migration period. This would increase the portion of juvenile fish collected and transported from the Snake River for release below Bonneville Dam. Because the portion of fish that are transported is already moderately high under existing operations, maximum transport would result in a modest increase in that number, and overall effects on Snake River listed stocks also would be expected to be moderate depending on survival of transported fish.

Effects on Juvenile Salmonids

The increase in portion of fish transported for Alternative 2—Maximum Transport of Juvenile Salmon relative to Alternative 1—Existing Conditions, may be as high as the difference between current fish passage efficiency (FPE) and the current portion of fish transported. Current estimates of the portion of fish transported from the Snake River are 54 to 68 percent for hatchery spring/summer chinook salmon, 62 to 75 percent for wild spring/summer chinook salmon, and 63 to 72 percent for hatchery and wild steelhead (NMFS, 1998). Under the current operation, estimates of FPE at these dams are 85 percent, 86 percent, and 61 percent at Lower Granite, Little Goose, and Lower Monumental dams, respectively (Technical Appendix A, Anadromous Fish). These values indicate the number of fish approaching each dam that do not pass through the turbine (i.e., they either pass through the spillway or are diverted from the turbine by screens and then collected for transportation downstream or released below the dam).

Current operating plans require spill ("voluntary spill") at each of these facilities at certain flows to "spread the risk" by passing some fish downstream through the spillway. Under Alternative 2—Maximum Transport of Juvenile Salmon, voluntary spill would be eliminated so that collection and transportation could be maximized. Decreased spill would likely reduce FPEs if fish guidance efficiency (FGE) is held constant because more juvenile fish remain near the surface and are more effectively passed downstream

by spill than by diversion using screens. The increased number of fish transported would be fairly small because currently most spring/summer chinook salmon and steelhead stocks are already transported (nearly 60 to 70 percent), at and it is unlikely that more than an additional 10 to 20 percent of these stocks would be transported. Additionally, it is estimated that no change from existing conditions would occur in the portion of fall chinook salmon transported (Marmorek et al., 1998a).

The primary difference between Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 1—Existing Conditions is that Alternative 2 would increase the benefits and deficits of collection and transport for an additional relatively small portion of spring/summer chinook salmon and steelhead in the Snake River. The benefits of transport include reducing in-river mortality (from dam passage, predation, and early arrival at the estuary). Deficits include such factors as potential increased straying, increased stress, and possibly delayed mortality. Likewise the benefits and deficits of in-river migration would be reduced (see Alternative 1—Existing Conditions). Additionally, the reduction of voluntary spill under Alternative 2 —Maximum Transport of Juvenile Salmon could have some benefit because dissolved gas would be reduced in the Snake River and possibly in portions of the Columbia River. This might benefit juvenile salmonids primarily during the spring season. However, since voluntary spill is limited to TDG concentrations not exceeding 115 to 120 percent, and these concentrations have not been shown to cause major problems for salmon or steelhead, this reduction would likely have minor benefits to anadromous stocks. Periodic elevated dissolved gas saturation would continue to an extent dictated by involuntary spill resulting primarily from high natural flows.

Effects on Adult Anadromous Salmon and Steelhead

A reduction in voluntary spill could result in reduced frequency of dissolved gas supersaturation distribution less than 115 to 120 percent and more often less than 110 percent. Lower saturations would reduce the potential for adverse effects to adult fish. High gas concentrations may impair fish swimming ability so a reduction could aid upstream migration rate. Also, high spill sometimes appears to be correlated with "headburns", a condition where open wounds are found on adult fish heads (Elston, 1996). This condition could be reduced if high spill is reduced. The level of spill that causes headburns is unknown, but usually is only common during above-average seasonal spills. However, involuntary spill can still occur, which is the major cause of the high dissolved gas saturations and possibly other effects that are harmful to adult salmonids.

Therefore, the overall effect of dissolved gas and high spill to adult fish is expected to be similar to Alternative 1—Existing Conditions.

Effects on Other Columbia River Anadromous Salmonids Including Federally Listed and Candidate Species

Effects on Columbia River anadromous salmonids would be the same as under Alternative 1—Existing Conditions.

Other Anadromous Stocks

Effects on American shad and Pacific lamprey would be the same as under Alternative 1—Existing Conditions.

5.4.1.3 Alternative 3—Major Systems Improvements

Alternative 3—Major System Improvements could have the greatest benefit to anadromous fish of the first three non-dam-breaching alternatives through the addition of surface bypass collector (SBC) systems at Lower Granite and/or other lower Snake River dams, and installation of ESBSs at Lower Monumental and Ice Harbor (see Section 3, Plan Formulation). The benefits of a fully operating SBC system might be relatively minor in terms of fish numbers bypassed or collected because the current intake screen systems are already efficient at collecting a high proportion of juvenile fish. However, the benefits of SBC technology extend beyond merely increasing the numbers of fish collected or bypassed. The potential benefit of an SBC is that it allows fish to pass the dam without sounding to the turbine intake and immediately being carried up near the surface again by upwelling flows in the gatewell. Rather, juvenile fish are allowed to stay at the level in the water that they prefer when naturally migrating.

Testing has not been completed on the prototype SBC at Lower Granite Dam. The SBC is only a partial powerhouse prototype and it was never intended to be a complete bypass structure. It was built to test fish reactions to various flows and entrance configurations so that a permanent SBC could be developed using the knowledge gained from the prototype.

Effects on Juvenile Salmonids

Based on results of ESBS tests at Lower Granite and elsewhere, some increase in survival would occur if ESBSs were installed at Lower Monumental and Ice Harbor dams. This increase would result from the higher percentage of fish that would be diverted away from the turbines. For example, FGE could increase from the current levels of about 60 to 70 percent for yearling chinook salmon to as high as 80 percent with new ESBSs (Marmorek and Peters, 1998a).

The PATH group estimated that the number of smolts transported from Lower Granite could be increased by 6 to 13 percent if the SBC system were as effective as the system at Wells Dam on the Columbia River, where 90 percent of the fish are passed through the spillway. While an SBC at Lower Granite is unlikely to reach the stand-alone performance that the Wells Dam system has achieved due to differences in project configuration and forebay flow characteristics, the performance of a system combining SBC and ESBSs at Lower Granite has, in fact, reached 90 percent.

Tests were initially conducted with a prototype, partial powerhouse SBC at Lower Granite in 1996 (Adams and Rondorf, 1999; Johnson, et al., 1999; Adams and Rondorf, 1998a and 1998b; Adams, et al., 1997). Based on promising initial results, a retest was conducted in 1997. Entrance gates on the SBC were also repaired between the 1996 and 1997 test seasons. Hydraulic and physical modeling, as well as test results from the first two test years, led to three major modifications in 1998. First, the Lower Granite turbine

intakes below the SBC were modified to make them more like those of Wells Dam. Second, a behavioral guidance structure (BGS) was added to the SBC (see Section 3, Plan Formulation). The BGS is a 1,100-foot-long floating steel "curtain." The BGS was attached to the south end of the SBC and extended upstream and towards the south shore. The purpose of the BGS was to divert fish away from the south half of the powerhouse. The third modification in 1998 was the addition of an entrance near the confluence of the BGS and SBC. It was thought that fish would concentrate in this area.

The BGS proved successful in showing the ability to divert 78 percent of the fish away from Units 1-3. SBC passage in 1998 was substantially improved from previous years, most likely as a result of structural modifications. Hydroacoustics determined that approximately 51 percent of the fish passing through Units 4-6 or the SBC went through the SBC (Johnson, et al., 1999). This value includes all species.

Radiotelemetry provided species-specific passage information. Of the radio-tagged fish passing through either Units 4-6 or the SBC, 29 percent of yearling chinook salmon, 49 percent of hatchery steelhead, 28 percent of wild steelhead, and 54 percent of subyearling chinook salmon used the SBC (Adams and Rondorf, 1998a,b). These passage efficiencies are likely lower than they would be if a full, permanent facility were to be designed and constructed. The prototype SBC has a relatively high effectiveness at diverting fish for the amount of water required to operate the facility. Typically, spill effectiveness is slightly over 1 (percentage of fish passing over spillway is a little more than the percentage of water over the spillway). SBC effectiveness at Lower Granite was measured at 7.1 in 1998 (Johnson, et al., 1999). While this is a fairly effective use of water for fish passage, it does not reach the performance of the surface bypass at Wells Dam, where approximately 90 percent of the fish pass in only 7 percent of the water (Johnson, et al., 1992).

The ESBSs recently installed at Lower Granite and the prototype SBC have improved the efficiency of diverting fish away from the turbines. (The FPE and FGE figures presented in this paragraph are from a very limited number of radio-tagged fish in 1998.)

One additional potential benefit of SBCs would be that they reduce time spent in the forebay by migrating juveniles, which often appear to mill around in this area or move back upstream before passing downstream. However, among alternative passage routes (e.g., turbine, spillway, SBC) the residence time of fish in the forebay does not appear to have been markedly reduced for fish using the SBC over the other routes (Adams and Rondorf, 1998a,b). Most residence time in the forebay was short for all routes during 1998, typically less than 6 hours for most fish. This may be because all of the SBC test years have been relatively high flow. A larger benefit in reduced residence time may occur in low flow years. The presence of the BGS also appears to reduce residence time. In 1998, the forebay residence times of all test fish were shortest when the BGS was in the deployed position (Adams and Rondorf, 1999).

Another potential benefit of the SBC is that it provides for passage that more closely mimics natural migration conditions. The SBC allows fish to move downstream past the dam without sounding to enter the turbine intakes and then move rapidly toward the surface when intercepted by an intake screen. In this respect, SBC passage would seem to be much more benign than either conventional bypass or spillway passage.

Dissolved gas concentrations could be greatly reduced by the use of SBCs. It may alleviate the need for large amounts of spill to achieve a high FPE at a project, thereby greatly reducing the amount of voluntary spill and associated high dissolved gas concentrations. Rearing and migratory habitat conditions would be similar to Alternative 1—Existing Conditions.

In summary, the overall effect of Alternative 3—Major System Improvements on survival of juvenile salmonids is likely to be increased over Alternative 1—Existing Conditions. While the number of additional fish potentially collected and transported compared to Alternative 1 is not large, this improvement could be significant if transporting fish proved to be a large benefit over in-river passage. The assumptions about benefits of transport versus in-river passage are discussed under Alternative 1—Existing Conditions and in Section 5.4.1.5, Model Analysis of All Alternatives. The as-yet-unknown stress-reducing benefits of SBC technology may also make surface collection a much more viable route of passage.

Effects on Adult Anadromous Salmon and Steelhead

Under Alternative 3—Major System Improvements, there could be a slight benefit to upstream migrating adult salmon and steelhead from the ESBS improvements and additions, and the installation of a SBC relative to Alternative 1—Existing Conditions. These facilities could reduce the frequency of fish that fall back through turbines and die. The relative loss of adults through turbine passage at Lower Granite is unknown, but considering that most fish do not fall back (about 93 to 97 percent), and that most fallbacks successfully ascend the fish ladder a second time (Bjornn et al., 1998), it is likely that the current number that are lost as a result of passage through turbines is low. Therefore, any reduction in losses by keeping fish from passing through turbines with major system improvements is likely to be minor relative to Alternative 1—Existing Conditions.

Effects on Other Columbia River Anadromous Salmonids Including Federally Listed and Candidate Species

Effects to Columbia River anadromous salmonids would not be changed markedly from Alternative 1—Existing Conditions.

Other Anadromous Stocks

American Shad

If the ESBS improvements and additions and the new SBC were to be operated into the fall season, they could benefit downstream migrating juvenile American shad by reducing their passage through turbines. Because this stock is not native, it may compete for resources with listed stocks, so any gain in this stock may be detrimental to listed stocks. It is anticipated that these systems would be operated during most of this period. This alternative would be beneficial to Snake River American shad individuals compared to existing conditions. However, the populations of shad have remained strong in the

Columbia River System under existing conditions. The total run of American shad into the Snake River is a small portion (likely less than 10 percent) of the total Columbia River runs. Therefore, any major system improvements in the lower Snake River, although they may benefit some individuals, would have insignificant effects on the overall population.

Pacific Lamprey

Some benefit could occur for downstream migrating Pacific lamprey, if they were successfully diverted with the SBC and/or the ESBSs instead of passing through turbines. However, this species appears to migrate in deeper water and could not encounter the SBC. Also, this species could become impinged on screens in the bypass systems. This could occur with ESBSs that would be installed at Lower Monumental and Ice Harbor and with screens needed to separate water from fish at the SBC. Overall, the net benefit, if any, of Alternative 3—Major System Improvements over Alternative 1—Existing Conditions can not be determined for Pacific lamprey.

5.4.1.4 Alternative 4—Dam Breaching

Alternative 4—Dam Breaching would eventually change what is currently a series of four reservoirs on the lower Snake River stretching over 140 miles to a river environment more closely approaching what is considered the "Normative River" concept (ISG, 1996). The process, however, would not be instantaneous and would require several years (estimated to be 3 to 8 years) before major changes in the environment are stabilized. The dam breaching and drawdown process would have some significant adverse effects to anadromous stocks destined for the Snake River in the short term. For example, short-term effects would continue for several years as the sediment that has been trapped behind the four dams is moved downstream through natural hydrologic processes and as other physical changes stabilize.

Part of this alternative would include actions intended to minimize detrimental short-term impacts through methods of decommissioning, timing of actions, and additional mitigation (see Section 3 and Technical Appendix D, Natural River Drawdown Engineering). Once the environment has stabilized, the long-term effects from this alternative should be beneficial to most Snake River anadromous stocks, although the relative overall gains have many uncertainties (see Section 5.4.1.5, Model Analysis of All Alternatives). Because short- and long-term effects are quite different, the following discussion presents these effects separately.

Short-Term Effects

A brief summary of dam breaching methods to be used is needed to help understand where and what types of effects could occur (see Technical Appendix D, Natural River Drawdown Engineering). The general schedule for dam breaching is expected to cover 8 or 9 years, with the drawdown and removal of two dams occurring in each of 2 consecutive years beginning year 5 or 6. To minimize effects to migrating anadromous fish, activities that could potentially affect them would be scheduled to occur between August and December each year.

Most juvenile salmon and steelhead outmigrate from spring through mid-summer (April into August), and many adults migrate upstream in the same period. While the period of removal overlaps with the major migration period of adult and some juvenile fall chinook salmon and adult steelhead, the chance of catastrophic events occurring from the risk of high flow in the January to March period, which is a period of lower numbers of upstream and downstream migrants, precludes scheduling removal during this period. The risk of harm to migrating fish resources is likely greater if removal did not begin until mid-December from the risk of massive uncontrolled bank erosion and reservoir drawdown if a high flow event were to occur during removal (see Technical Appendix D, Natural River Drawdown Engineering).

In the breached dam area, river flow would be directed through a fairly narrow opening where water velocity could be much higher than it is in most of the river. Also, post drawdown, riprap would be placed along about 25 percent of what would be the future shoreline, thus altering shoreline characteristics. Following breaching, much of the accumulated sediment behind each dam, with the most behind Lower Granite, would move downstream as suspended sediment and bedload like a long dynamic wave, depending on sediment size fractions (see Section 5.3, Water Resources). Eventually, it is expected that most of the new unimpounded river reach would consist of cobble/gravel substrate interspersed with sections of bedrock/cobble and gravel/sand. High flows (often over 200 kcfs) would be required to remove imbedded sediment and return the riverbed to its original substrate composition. It is expected that much of the sediment would deposit in McNary pool over a 5-year period following dam breaching. However, some areas in the lower Snake River could retain sediment for up to 10 years (Hanrahan et al., 1998).

Suspended Sediment Effects

Suspended sediment resulting from dam breaching could have adverse effects on all aquatic organisms present in-river, particularly during the first 5-year period. Most recent estimates (based on models and re-estimates of total sediment) suggest peak suspended sediment concentrations would increase downstream through the reach with lowest peaks in Lower Granite of 3,600 to 9,000 milligrams per liter (mg/l) in the vicinity of Ice Harbor Dam (Foster Wheeler Environmental, 1999a). Sediment modeling for the SOR (BPA et al., 1995) dam removal alternative estimated that 25 mg/l (a level below which it is considered safe for most salmonids for moderate time periods) (Newcombe and Jensen, 1996) would be exceeded by about 36 percent of the time in the first year and by about 15 percent for the next 15 years. This compares to no modeled exceedence of this concentration under Alternative 1 (Technical Appendix C, Water Quality). However, the model used to make these estimates was based on an approximation that had only 30 percent of the accumulated sediment currently predicted to be behind these dams. Therefore, the concentration and frequency of exceedence of this amount are likely to be much higher and at least double the most recent estimates developed for the SOR.

Alabaster and Lloyd (1982) reviewed the effects of sediment on fish and concluded there was ample evidence that concentrations of 200 to several thousand mg/l might cause deaths to fish exposed for several weeks or months. For short-term exposure (usually less than 6 days), concentrations in excess of 3,000 to 20,000 mg/l might cause some

death of salmon and trout (Newcombe and Jensen, 1996; Newcombe and MacDonald, 1991; Alabaster and Lloyd, 1982; Servizi and Martens, 1987). Lloyd (1987) found concentrations less than 80 to 100 mg/l for extended periods were moderately tolerated by salmon and trout. Some feeding rate reduction has been observed for coho salmon at concentrations of 25 mg/l (Noggle, 1978). Newcomb and Jensen (1996) noted mortality of sac-fry stage at suspended sediment concentrations as low as 20 mg/l when exposed for 4 days. Generally, aquatic insects and younger salmonids are more sensitive to suspended sediment than adult salmon or trout (Newcombe and MacDonald, 1991; Newcombe and Jensen, 1996).

Newcombe and Jensen (1996) reviewed hundreds of documents concerning sediment and developed predictions on types and severity of effects to salmonids based on concentration and duration of sediment exposure. Based on this review, the authors predicted that sediment concentrations in the range of about 20 to 50 mg/l for about 2 to 7 weeks would result in factors such as reduced feeding, poor condition, and major physiological stress to salmonids. This is in the range of values expected to exist for at least the first year after each drawdown and likely for reduced periods for several years after. Also, based on the Newcombe and Jensen (1996) model, if peak concentrations indicated 3,000 to 9,000 mg/l were maintained for a week, some direct fish mortalities would occur. These high concentrations would be expected to occur primarily during the drawdown period (August to December) and possibly during periods of high runoff in the spring (April to June). These concentrations would be most likely during the first year or two during and following drawdown.

While suspended sediment would have general effects on overall survival, other factors in the short term would affect conditions for both juveniles and adults. The following sections summarize these effects, including additional effects of sediment as they relate to specific issues for juvenile and adult salmonids.

Effects on Juvenile Salmonids

In the short term, some beneficial conditions would aid survival of juvenile salmonids including, for example, likely increased migration rates and elimination of mortalities associated with dam passage. In addition, increased sediment and turbidity could provide more favorable cover from predation. Several negative factors would also affect juvenile fish including direct effects of suspended sediment, reduced fish transport, reduced habitat quality, and decreased food supply.

Flow and Water Velocity

With dam removal, increased water velocities in the lower Snake River would increase the migration rate of all juvenile salmonids through this reach up to six-fold in any one flow year (Wik et al., 1993). The increase would likely vary somewhat from the long-term conditions because other factors such as turbidity, food supply, and relative change in hydrology within the reaches as sediment stabilizes could influence migration rate. The possible overall effects of the physical changes on migration rates are discussed in the Long-term Effects section.

Dam Passage and Transportation

While juvenile spring/summer chinook salmon and steelhead would migrate out of the Columbia River System prior to the beginning of scheduled drawdown and removal periods (August to December), some subyearling fall chinook salmon and sockeye salmon would still be outmigrating during these operations. The changes in dam passage conditions during the removal period could adversely affect these stocks.

The dams would be in a state of transition from full pool to river conditions, and normal operations at these facilities would not be possible. Turbines would operate at less than maximum efficiency, spill conditions would be altered, and transportation of fish would not be possible from the facilities being removed. All of these conditions could significantly increase mortality of fall chinook salmon and sockeye salmon outmigrating during the 2-year removal period. Loss of transportation would also increase direct mortality of fish of all stocks not transported, although the apparent effects on indirect mortality (i.e., "delayed transport mortality") would be reduced. See Section 5.4.1.1, Alternative 1—Existing Conditions and Section 5.4.1.5, Model Analysis of All Alternatives, for discussion of transportation effects.

Dissolved Gas Supersaturation and Sediment Contamination

TDG could reach adverse saturation and distribution normally in the spring, under current conditions from spill over dams. Therefore, potential adverse effects of supersaturated gas would be reduced in the Snake River without the dams. This is discussed in more detail under Long-term Effects.

Initial evaluation of potential contaminants in reservoir sediments (e.g., metals, miscellaneous organics, pesticides) predicted that only two compounds (DDT and dioxin) relating to aquatic organisms or human health, could be elevated following sediment movement (Foster Wheeler Environmental, 1999a). Study results indicated concentrations of these compounds likely to occur in the four reservoir areas and in McNary pool would remain at safe concentrations for aquatic organisms and human health risk, even during periods of greatest sediment movement.

Predation

Drawdown would affect factors that would likely both increase and decrease predation rate in the short term. Initial drawdown would likely increase predator density as the populations currently present in the reservoirs would initially be concentrated in a much smaller surface area and water volume. This could increase the predation rate on migrating fish. However, increased turbidity during drawdown would reduce predator efficiency at capturing juvenile salmonids. Gregory and Levings (1998) examined predation rates in clear and turbid river systems in British Columbia. They found that predation with turbidity in the range of 27 to 108 nephelometric turbidity units (NTUs) during the spring was greatly reduced compared to turbidity of less than 1 NTU. Currently, turbidity in the Snake River reservoirs during the spring season ranges from about 10 to 30 NTUs. During periods of lower flow, it is likely in the range of 5 to 10 NTUs (see Technical Appendix C, Water Quality; Corps, 1992). These amounts would likely be much higher during the short term, especially during the first 2 to 3 years following dam breaching, which would help reduce predation.

The short-term effects of drawdown directly on predator populations within the lower Snake River is not clear. With disturbed conditions, the environment would be worse in some ways for the predators (disturbed bottom, shoreline, elevated turbidity) which could reduce their populations and ultimately predation on migrating juvenile salmonids. This is especially important for fall chinook salmon, which appear to suffer high mortality from predation within this reach, while there appears to be low predation rates on spring/summer chinook salmon and steelhead within the reservoirs of the lower Snake River dams (Petersen et al., 1999). Predation is discussed in more detail under Long-term Effects.

Changes in water temperature following drawdown could also influence predation. Temperature change are discussed in more detail under Long-term Effects.

Rearing and Migratory Habitat

The short-term effects of turbidity and moving sediment would likely be most detrimental to rearing fall chinook salmon, which is the only stock that spends substantial time (typically 2.5 to 4 months) rearing in the mainstem lower Snake River. Currently, most of this rearing period occurs upstream of lower Snake River reservoirs. Effects of suspended sediment would likely severely limit rearing in the lower Snake River for juvenile fall chinook salmon for at least the first year or two following dam removal. However, this long duration of rearing in the Snake River mainstem may not be the normal condition of the original native fall chinook salmon stocks in the Snake River system (Waples et al., 1991). These fish, and possibly some of those still present, may have moved downstream and out of the Snake River System in the spring to rear before outmigrating to the ocean at a later date. Nearshore bottom areas that supply a benthic food source to migrating juvenile fish would likely be poor during the first few years following removal. With continual movement of sediment during higher flow, the shallow water and backwater areas that are often used by rearing fish would often have new sediment added, burying benthic food supplies. Also, without reservoirs, pelagic food sources that fall chinook salmon use when available (Curet, 1993) would be absent.

Juvenile fall chinook salmon could also become stranded in pools as the reservoir elevations are reduced. Currently, the plan is to reduce the reservoir elevations 2 feet per day for an 8-week drawdown period. It was found during the test drawdown in 1992 that some 15,000 resident fish (only 11 salmonids) were stranded when water elevation was reduced 30 feet in March, a time when few migrating salmonids would be expected in the reservoirs (Wik et al., 1993). By August, few spring/summer chinook salmon or steelhead are passing downstream at these reservoirs. However, fall chinook salmon and sockeye salmon continue to outmigrate into November and could be present during drawdown. By mid-summer, fall chinook salmon are rarely found near the shore (Curet, 1993) where potholes for entrapment would occur during drawdown. Therefore, losses from stranding during drawdown would likely be minor.

Effects on Adult Anadromous Salmon and Steelhead

Upstream Passage

Four factors could influence the success of upstream migration during the short term: 1) sediment concentrations, 2) passage around breach and shoreline protection structures, 3) access into tributaries, and 4) water temperatures. Sediment concentrations have the greatest potential for impact during the short term. Upstream migration could be impeded during high suspended sedimentation periods. Highest concentrations of suspended sediment would likely occur during initial drawdown (August to December) during the dam removal period and then again during high flow, typically April through June. This spring increase would reoccur annually for several years after removal, but with decreasing intensity. Brannon, et al. (1981) found reduced preference of adult chinook salmon to homing water when concentrations of volcanic ash reached 350 mg/l. Following the eruption of Mount St. Helens, straying of nearly all Toutle River anadromous stocks occurred apparently from sediment in the range of 300 to 75,000 mg/l, although lower concentrations (600 to 18,000 and 28 to 8,700 mg/l) also appeared to result in fish straying (Martin et al., 1984). These effects may not be permanent, however. For example, Schuck and Kurose (1982) reported that even with elevated levels of sediment in the South Fork Toutle following the first and second winter after the eruption, many steelhead ascended the river to spawn.

While the expected suspended sediment concentrations under Alternative 4—Dam Breaching would likely be in the lower range of the critical values (likely concentration and duration) found in the literature (Newcombe and Jensen, 1996), some impacts to migration are likely to occur. It is likely that during at least the years of removal operations, delays in upstream migration or straying might occur with at least fall migrating fish (some fall chinook salmon and steelhead). Also during high flow periods in the spring, some spring/summer chinook salmon could be delayed or stray. The frequency should decrease significantly after the dam breaching operations are complete, but could continue for several years at lower intensities in the spring. Considering sediment conditions and other factors, it is possible that 50 percent of the adult annual escapement could be partly disrupted for the first 2 to 5 years during and following breaching.

Blockage of upstream migration at the dams could occur in the fall/winter period during the years that dams are breached. This period includes major migration of fall chinook salmon and steelhead. While dams are being drawn down, passage facilities would be inoperable. Blockage could affect those fish that migrate to the Tucannon River, those that return to the Lyons Ferry Hatchery, as well as fish destined for locations upstream of Lower Granite. However, specific actions would be implemented to insure that fish move upstream during the removal period (See Technical Appendix D, Natural River Drawdown Engineering). The current two-tiered, two-dam removal plan, recommends truck transport of adult fish around the construction region. This would likely include collection of adults at Ice Harbor Dam and Little Goose Dam during the respective two-dam removal periods. Capture and release of adult fish has its own risks. For example, transporting adult fish by truck could result in increased risk of disease, stress, or injury, especially during periods of warm water (e.g., 70°F) in August when fish are taken from warmer river water, transported in trucks where water temperatures are cooler (through

chilling), and then released again in warmer river water downstream of Bonneville Dam. This could result in increased mortality. Also, any unmarked fish destined for tributaries to the reservoirs (e.g., Tucannon River) or adults that spawn in tailraces (e.g., fall chinook salmon) would be transported upstream. Additionally, during some years the peak daily count of fish may exceed 4,000 fish, which could tax daily available truck transport capacity.

Physical impedance of adult movement past the current dam sites would not likely occur following dam removal (see Long-term Effects). This is because upstream fish movement normally stops at flows of about 170,000 cfs, which are expected to occur once every 5 years. The current breach area would be designed to provide velocities through the breach that would not impede upstream fish movement at flows less than 170,000 cfs.

As reservoirs are drawn down, deltas at the tributary mouths could be temporarily impassible. An impassible delta was observed at Alpowa Creek during the 1992 drawdown test (Schuck, 1992) of Lower Granite. However, erosion rates could be rapid as flow increases, especially at larger streams like the Tucannon River. This would likely make the tributary more passable.

Restricted access to tributaries could have its greatest effect during early fall (August and September) when tributary flows are at their lowest. This would primarily affect steelhead and fall chinook salmon that could enter these streams in the fall. Based on experience at drawdown tests on Lower Granite and the Elwha River, it appears that passage would not likely be a problem on the mainstem Snake River or Clearwater River as the erosion would proceed rapidly, and develop a passable channel (USFWS, 1998a).

Changes in water temperature and dissolved gas could also influence migration success. The likely temperature and dissolved gas effects on migration are discussed under Long-term Effects.

Spawning and Overwinter Habitat

In the short term, spawning habitat for tailrace spawning fall chinook salmon would be disrupted. From 1993 to 1997, from 1 to 18 redds have been observed in the tailrace areas below Lower Granite and Little Goose dams (Dauble et al., 1999). Other lesser used spawning areas are present below Lower Monumental and Ice Harbor dams. These areas would likely be lost as spawning areas either from sediment movement, dam breaching activities, or changes in velocities. The spawning fish that utilize these breaching areas, however, are a very small portion of the total spawning population of fall chinook salmon.

As sediment and channels begin to stabilize, spawning habitat within the lower Snake River would gradually increase following dam breaching. The fluvial processes of sediment redistribution, channel cutting, and flushing of fines would develop a riverine environment including suitable spawning gravel and cobble, mostly free of excessive fines, after about 5 years (Hanrahan, et al., 1998). Some spawning habitat would likely develop sooner, depending on flow magnitude high enough to produce sheer stress forces to deconsolidate and clean cobbles and gravels (>200 kcfs) (Hanrahan, 1999). This prediction is based on models developed for dam removal on the Elwha River (USFWS,

1998a) and on actual observations of spawner use in heavily sediment-impacted regions of the South Fork Toutle River a few years after the Mount St. Helens eruption (Lucas, 1985; Lucas and Lock, 1991). Current predictions are that 23 to 24 percent of the lower Snake River reach could have potential spawning habitat conditions (BRD, 1999). However, for several years the high fine sediment concentrations in the sediment would likely greatly reduce spawning success and egg survival. Movement of fine sediments (<0.84 millimeter [mm]) over spawning areas after spawning would further reduce egg survival. High concentrations of fines in spawning areas are known to be highly detrimental to egg survival (Chapman and McLeod, 1987; Diplas and Parker, 1985; Young, et al., 1991; Tappel and Bjornn, 1984).

Fall chinook salmon have been found to use new spawning areas as they become available. During the early years after dam breaching is complete, fall chinook salmon from fish produced upstream would likely use some of the developing spawning habitat in the lower river, especially around reformed islands. Many of the fine sediments would not have stabilized in the early years after dam breaching is complete, especially if high flows occur. New areas used for spawning could produce poor survival which could result in lower than normal production of fall chinook salmon using these areas.

Adult steelhead could be displaced or lost during the 2 years of fall drawdown because, under existing conditions, several thousand steelhead overwinter in the Snake River reservoirs before migrating upstream to tributaries to spawn the following late winter or spring. As reservoirs are drawn down, this overwintering habitat would be lost and would not be available following drawdown. These overwintering fish could be forced to move up or downstream to find other overwintering habitat and survival of these fish could be reduced.

Effects on Other Columbia River Anadromous Salmonids Including Federally Listed and Candidate Species

During dam breaching and several years following, some adverse effects could occur to anadromous stocks in the mainstem Columbia River. The effects would primarily result from elevated suspended sediment and reduced rearing and migratory habitat quality. Some Columbia River Federally listed species would be affected.

It is predicted that increased suspended sediment concentrations would be highest in the vicinity of Ice Harbor following dam breaching. Levels of up to 9,000 mg/l could occur (Foster Wheeler Environmental, 1999a). These levels would likely decrease in the Columbia River where flow is typically twice that of the Snake River, which would reduce the concentrations. As water enters the McNary pool, sediment traveling as bedload and fine suspended sediments would settle out.

Suspended sediment concentrations would be decreased by settling of sediment behind McNary Dam. Estimated peak values at McNary Dam are estimated to be about 80 mg/l (Foster Wheeler Environmental, 1999a). The result would be that most of the effects would be limited to McNary pool, with some increased turbidity extending downstream to the mouth of the Columbia River. As noted previously, the period of largest effects would be during the first fall seasons (August to December) and the following spring seasons (April to June) after each drawdown.

Juvenile Salmonid Rearing and Migratory Habitat

Short-term effects described for juveniles in the Snake River as a result of increased sediment would be similar for juveniles in McNary pool, but to a much reduced level. Some reduction in habitat quality would occur in McNary pool from burial of substrate by a predicted 24 million cubic yards which is expected to settle in lower velocity areas, mostly near the mouth of the Snake River. This area is typically shallow and provides rearing habitat for primarily subyearling chinook salmon which would include Hanford Reach fall chinook salmon, and, to a lesser extent, Snake River fall chinook salmon and Columbia River summer chinook salmon. Other upriver stocks use the region mainly as a migration corridor and spend little time in the region. The burial of these shallow areas with over a foot of sediment (Technical Appendix C, Water Quality) would eliminate benthic production during the first year and likely for a few years following dam breaching.

The effects of suspended sediment on juvenile salmonid rearing and migratory habitat would not likely be minor, especially below McNary pool. The U.S. Fish and Wildlife Coordination Act (FWCAR) predicts that a large proportion of the current backwater and/or shallow water open-sand habitat currently used by rearing fall chinook salmon in McNary Reservoir would be converted to wetland habitat due to filling by silt. However, some reduction in predation by fish and birds could occur from elevated turbidity entering the downstream areas (Gregory and Levings, 1998). These benefits could extend downstream, diminishing at each pool as more fines settle out. Increased turbidity could reduce primary production, which could reduce zooplankton production, a food source for many juvenile salmonids. Other than the area near the mouth of the Snake River, elevated levels of suspended sediment are unlikely to reach concentrations and durations considered directly harmful to fish.

Under Alternative 4—Dam Breaching, reduced TDG in Snake River water entering the Columbia River could be a positive effect for fish in downstream areas. However, mortality from elevated dissolved gas concentrations under normal operations has rarely been documented in recent years. Therefore, overall benefits that might increase survival could be minor except during periods of extremely high flow. The effect would be to reduce the risk of very high gas concentrations occurring.

Adult Salmonid Upstream Passage

Migration of adults in the Columbia River past the mouth of the Snake River could be delayed for brief periods primarily in the first 2 years of dam breaching, with greatly reduced effects thereafter. Elevated suspended sediment has been found to cause avoidance of and delay in adults returning to natal streams (Brannon, et al., 1982). This could primarily affect upper Columbia River adult summer and fall chinook salmon (those destined to migrate upstream of McNary Dam) from August to December, and to a lesser extent, spring chinook salmon during high runoff in the two spring seasons following dam breaching. Some water temperature changes could occur in the Columbia River, partly due to increased suspended sediment effects (see Long-term Effects).

<u>Summary of Effects to Columbia River Listed Anadromous Fish</u>

In summary, for the other listed or candidate anadromous fish in the Columbia River System (Table 4.5-2 in Section 4.5, Aquatic Resources), short-term effects under Alternative 4—Dam Breaching have the potential to be adverse likely only on the upper Columbia River Spring Chinook Salmon and Upper Columbia River Steelhead ESUs. Fish from these ESUs would pass by the mouth of the Snake River and could be affected by elevated concentration and duration of sediment, as discussed previously. These effects are expected to be minor because the overall effects of suspended sediments in this portion of the Columbia River, other than habitat burial, would also be minor. Other listed or candidate stocks are far enough downstream that any effects of sediment would be very minor and possibly beneficial by providing cover from predation during downstream migration of juveniles. Likely benefits of reduced dissolved gas in water flowing out of the Snake River are likely to have very minor, if any, effects on fish downstream of McNary Dam.

Other Anadromous Stocks

<u>American Shad</u>

Negative effects would likely occur to American shad during the short-term period of dam breaching and channel recovery. This would be a slight benefit to native anadromous fish which may compete for resources with this abundant introduced stock. Shad rear in reservoirs and outmigrate in the fall. Dam breaching would eliminate the reservoirs during much of their rearing and part of their outmigration period. This could reduce their survival because habitat quality would be reduced and suspended sediment could be directly harmful to their survival. The river habitat developed immediately after dam removal with its elevated suspended sediment and less stable substrate could be less conducive to shad because they have not been found in high numbers in Columbia River tributaries. However, dam breaching could enhance downstream passage survival (e.g., no turbine mortality) and eliminate structures (e.g., dams) that impede upstream migration. This could, however, be negated by increased water velocities in the drawn down reach.

<u>Pacific Lamprey</u>

Tolerance of lamprey to suspended sediment is not well known, but is likely greater than that of salmonids because their juvenile life stage includes residence in stream sediment. Increased sediment could affect adult migration success, but it is unknown if this would be positive or negative. Also, any juveniles (also known as ammocoetes) that could have resided in the reservoirs would likely be displaced or lost during drawdown. Juvenile lamprey are expected to reside primarily in tributaries or rivers and not in reservoirs (BPA et al., 1995). Therefore, any losses would be expected to be minor. Outmigration of juvenile lamprey appeared lower in 1992 following the drawdown test, suggesting that some individuals could reside in the reservoir. However, Pacific lamprey could benefit in the short term from dam breaching which could enhance downstream survival because they do not use salmonid bypass systems at the dams to any great extent (Hatch and Parker, 1998; Close et al., 1995).

Long-term Effects

Overall, long-term effects of Alternative 4—Dam Breaching are primarily beneficial to most anadromous species destined for the Snake River. The following section presents a qualitative assessment of the long-term effects that could occur under Alternative 4—Dam Breaching and discusses some of the uncertainties within specific issues.

Effects on Juvenile Salmonids

Flow and Water Velocity

The migration rate of juvenile salmonids through the lower Snake River could increase once drawdown is complete. Also, any passage delays presented by reservoirs and dams would be eliminated. Without dams, the water velocity through the whole reach would increase dramatically. For example, at flows of about 120 kcfs, travel time of water through this reach is about 175 hours. This would be shortened to 30 hours if dams were breached. Since the rate of juvenile migration downstream appears to be related to flow (FPC, 1999), the rate of migration for yearling fish should be faster under the free-flowing conditions. However, these faster rates could not apply to subyearling fall chinook salmon because their migration rates through reservoirs are not always correlated with flow rate (Muir et al., 1998; Giorgi et al., 1997). The effects of these possible changes in migration rate, if any, on survival are addressed in Section 5.4.1.5, Model Analysis of All Alternatives.

Migration rates in a free-flowing lower Snake River would likely be similar to rates of fish passing through similar areas of the Snake River upstream of Lower Granite. Estimates of migration rates for steelhead in the free-flowing river upstream of Lower Granite are about 2 to 3 miles per hour, while migration rates through Lower Granite Reservoir are about 1 mile per hour (Technical Appendix A, Anadromous Fish). There also are indications that the migration rate of subyearling chinook salmon could be faster in the portion of the river upstream of Lower Granite Reservoir than within the reservoir itself (Technical Appendix A, Anadromous Fish).

Results of studies by Muir, et al. (1998) showed that the migration rate for subyearling chinook salmon was about 2.1 miles per day for fish released 104 miles upstream of Lower Granite, while it was 1.3 miles per day for fish released 65 miles above Lower Granite Dam. This could indicate that fish migrated faster in the free-flowing portion of the river and then slowed through the reservoir. However, this could not be the case because the migration rate through the reservoirs downstream, with no flowing river segments, was much higher—greater than 6 miles per day. Therefore, while some information suggests that the rate of migration for subyearling chinook salmon could be faster with a free-flowing river, other factors such as temperature, turbidity (Muir et al. 1998), fish development, and size could also play a major role that could not be influenced by changes in conditions from reservoir to river.

Recent estimates of survival of fall chinook salmon through the free-flowing reach of river upstream of Lower Granite were quite high for hatchery fall chinook salmon, at 99.9 percent survival per mile. This estimate appears to be greater than survival estimates for passage through the reservoirs (USFWS, 1998a). The USFWS (1998a)

concluded that migration rates would likely be much greater without the reservoirs for all anadromous salmonids and that survival would likely be greater under these conditions for subyearling chinook salmon.

Elimination of Dam Passage and Transportation

Under Alternative 4—Dam Breaching, mortality for in-river migrants within the lower Snake River would be reduced substantially (Marmorek and Peters, 1998a). However, when loss of transport is considered, overall direct downstream passage mortality (in-river plus transport) would be increased relative to Alternatives 1, 2, and 3 for most stocks.

Passage at each dam adds a mortality rate of about 2 percent for bypass systems, 10 percent for turbines, or 2 percent for spillways. These causes of mortality would no longer exist in the lower Snake River.

Fish transportation would also be eliminated from the lower Snake River with this alternative. The current estimate of direct mortality is 2 percent due to transport from collection sites and release below Bonneville Dam. As discussed previously, about 50 to 65 percent of juvenile spring/summer chinook salmon and steelhead from the Snake River are currently transported, and about 85 percent of Snake River fall chinook salmon have been transported annually since 1992. Without transportation, the mortality from migrating downstream through the lower Snake River and then through the four lower Columbia River dams would be much higher than 2 percent direct mortality estimated for transported fish. As discussed in Section 5.4.1.5, Model Analysis of All Alternatives, the question of total mortality of transported fish is dependent on the estimates of how much additional mortality (differential delayed transport mortality) occurs after transported fish have been released compared to fish that are not transported. As stated by NMFS (1999c), this is one of the prime questions that can not be accurately determined with available data.

Dissolved Gas Supersaturation

Dissolved gas concentrations, which often reach 115 to 120 percent and occasionally over 130 percent, can be harmful to rearing and migratory juvenile anadromous salmonids. For example, total dissolved gas concentrations during much of the spring and early summer were above 120 percent for about one and a half months in 1996 and 1997 near the mouth of the Snake River, and greater than 125 percent for much of this time. During these periods, signs of gas bubble disease were reported in some migrating fish (FPC, 1999). Without the lower Snake River dams, over the long term, these high concentrations of TDG would not be present in this area. Although some elevated TDG (currently about 108 to 110 percent in Lower Granite pool) could be developed from spill at upstream dams (e.g., Hells Canyon and Dworshak), the TDG would likely be reduced to near saturation (i.e., 100 percent) in the lower Snake River.

Current saturations are not considered to be causing mortalities. Unfortunately, these estimates can not be verified at this time. Therefore, some benefits from reduced gas supersaturation would occur for Snake River fish. Little effect would occur to Columbia River fish because the Snake River flow remains along the Oregon side of the river and

fish moving upstream pass mostly on the Washington side. These benefits would likely be greatest for juvenile migrants that pass through the lower Snake River because of their potential for cumulative exposure to elevated TDGs.

Predation

Over the long term, predation on juvenile migrants after dam breaching is completed should be less than under current conditions. However, the exact overall magnitude of change is not well defined. Under current conditions, the primary predators on juveniles in the reservoir areas are northern pikeminnow and smallmouth bass. Predation is often considered highest near the forebay or tailwater of reservoirs. The increased travel time through reservoirs often increases the opportunity for predation. During periods of high water temperatures, predation also increases greatly in reservoirs and rivers.

Petersen et al. (1999) developed a model that analyzes the potential predation rate in the lower Snake River. To do this, the authors determined the abundance of pikeminnow and smallmouth bass in both the reservoir and river environment. Based on studies from the Hanford Reach and the Snake River upstream of Lower Granite, the authors estimated the future populations of these predators in the lower Snake River under unimpounded river conditions.

Using the EPA estimate of future water temperatures under unimpounded river conditions (Yearsley, 1999), expected prey and predator abundance, and knowledge of feeding habitats and bioenergetics of the two prey species, Petersen et al. estimated the current and future predation rates within the lower Snake River during spring and summer seasons. The spring season represents the period of primary migration of spring/summer chinook salmon and the summer season primarily represents fall chinook salmon and some sockeye salmon migrants.

Petersen, et al. (1999) then estimated that within the lower Snake River reach, the current northern pikeminnow population would double and smallmouth bass would decrease by 50 percent under unimpounded river conditions. Under current conditions, predator consumption in the reach during the spring season (April to May) is only 1 percent of the migrating juvenile spring/summer chinook salmon population. In contrast, estimated predator consumption of summer migrants within reservoirs is high, at 59 percent. The authors predicted that the change to a drawn down river environment would result in a reduction in the rate of predation by 74 percent during the spring season and 83 percent during the summer. The change in predation rate was based on predictions of change in diet, predator population sizes and structure, and temperature (Petersen et al., 1999). Based on these values, the overall reduction in absolute predation rate for spring migrants under flowing river conditions was estimated to be reduced from about 1 percent currently to less than 1 percent after drawdown. The reduction in summer predation rate would be larger, ranging from 59 percent to 10 percent after drawdown for fall chinook salmon and late-migrating sockeye salmon.

If the Petersen et al. (1999) model is correct, the greatest benefit from the change to free-flowing river conditions would be for summer migrants. It should be noted that this model is only in draft form and some other studies suggest quite different changes in predator populations with dam breaching and changes in temperature (Technical

Appendix B, Resident Fish; Technical Appendix C, Water Quality). Changes in existing populations of predators could also alter the predictions. For example, Technical Appendix B, Resident Fish presents estimates that the northern pikeminnow population would decrease by half, while smallmouth bass would double under free-flowing river conditions reflective of smallmouth bass densities currently found in the unimpounded Snake River above Lower Granite Reservoir. This is the opposite of what is predicted by Petersen et al. (1999). With the estimates provided in Technical Appendix B, Resident Fish, there would likely be much less change in summer predation rates between reservoirs and the drawn down river conditions.

Water temperature greatly influences predation rate. As temperatures increase, predation rates also increase. Predictions of water temperature changes under Alternative 4—Dam Breaching differ considerably between authors. Yearsley (1999) predicts that with dams removed, the days when water temperatures are greater than 68°F would decrease from about 20 percent to 13 percent at Ice Harbor. For days when temperatures exceed 68°F, the average increase in summer temperatures in excess of 68°F at Ice Harbor would decrease from current 3.2°F to 2.2°F (a net average reduction of 1.1°F). Yearsley's (1999) conclusions are based on a model that uses data from 1990 through 1995.

Historical records indicate that some of the highest temperature periods in the Snake River occurred prior to construction of the lower Snake River dams (Chapman et al., 1991). The most noticeable effect of the Snake River dams on water temperature has not been the magnitude of change. Rather, it has been the timing of the temperature changes (Technical Appendix C, Water Quality). Generally, peak temperatures (usually considered greater than 68°F) occurred from mid-July through August prior to construction and operation of the dams. This peak shifted to August through September after dams became operational (Technical Appendix C, Water Quality). Based on historic information, peak temperatures before the dams were built ranged from 79 to 81°F (or about 4 to 9°F) higher in July through August than under existing conditions (Technical Appendix C, Water Quality). Temperature modeling by the Corps (Technical Appendix C, Water Quality) indicated that during low flow years, water temperature under free-flowing or drawn down river conditions would drop in the fall much faster (15 days sooner to 59°F) than under current conditions.

Also in recent years (since 1995), flow releases from Dworshak Reservoir—primarily for flow augmentation—have contributed to lower temperatures in the Snake River reservoir areas, which likely contribute to decreased predation in the lower Snake River. However, the future release of this water may change because there are various demands for its use (see Adult Anadromous discussion under Alternative 1—Existing Conditions subsection). If additional releases from Dworshak continue under dam breaching, they would likely reduce temperature even more than they do currently because it would constitute a larger portion of total water volume in this reach. This may reduce predation over current conditions.

The effects of the predicted temperature changes on predation are not completely clear because the overall change in temperature is difficult to determine. While Petersen et al. (1999) predicts changes in predation rate based on the Yearsley (1999) model, the actual changes could differ depending on flow year and depending on where flow enters the river (i.e., releases from Dworshak or Hells Canyon). In general, however, decreased

temperatures during the migration season would tend to decrease predation, but the precise percent decrease or increase is uncertain.

Rearing and Migratory Habitat

The newly formed and stabilized 140-mile river environment under Alternative 4—Dam Breaching would be more typical than reservoirs of the habitat used by Columbia River fall chinook salmon for rearing prior to outmigration. The substrate and flow conditions would be more conductive for producing food resources (e.g., benthic insects) commonly consumed in river environments by salmonids. The development of a more complex environment including pools, riffles, runs, and rapids would also likely develop both more diverse and possibly more abundant food resources. The food supply for fish in a free-flowing river is more typically composed of mayflies, midges, and caddisflies.

Terrestrial insects would also make up a larger portion of the diet as the riparian area develops along the streambanks (Technical Appendix M, Fish and Wildlife Coordination Act Report). However, this would be very long-term as southeast Washington climate and rock soils are less conducive to extensive riparian coverage along the shoreline of a river, even the size of the historic Snake River. Caddisflies, a typical flowing water benthic insect taxa eaten by fall chinook salmon, supply a much greater energy source for subyearling fall chinook salmon than Daphnia, a zooplankton, which is more typically consumed in the Columbia River reservoir environments (Rondorf, et al., 1990). A shift in temperature to higher temperatures earlier in the summer under Alternative 4—Dam Breaching, as predicted in Technical Appendix C, Water Quality, could result in more rapid outmigration of fall chinook salmon or make conditions less suitable for fall chinook salmon rearing earlier in the summer. This earlier outmigration may be similar to the life history pattern noted by Waples et al. (1991) prior to river development. Also, the addition of riprap along about 25 percent of the reconstructed shoreline near breached areas could reduce the quality of cover and rearing habitat more intensively used when fall chinook salmon first emerge from the gravel. GIS analysis (BRD, 1999) indicates only about 42 percent of shoreline in the 1934 lower Snake River reach (140 miles) met criteria for subyearling rearing as reported from studies conducted since 1986 (Bennett et al., 1987-97). Forty-two percent of shoreline equates to only 5 percent of total wetted perimeter area. Overall, the net effect on rearing fall chinook salmon under Alternative 4—Dam Breaching is not possible to predict.

Effects on Adult Anadromous Salmon and Steelhead

Upstream Passage

The overall migration rate through the lower Snake River is unlikely to change significantly from current rates. Bjornn et al. (1998) noted that while some delay occurs at dams, fish migrate faster through reservoirs than it is estimated they would have through the pre-dam river. In a natural river system, fish normally stop and go, pausing below rapids and falls, and cruising through slower pools. Because of this behavior, it is reasonable to expect that fish would take longer to pass through a 30- to 35-mile reach of river than it would take to pass through a reservoir. Because of this behavior, the authors

indicated that the lower Snake River facilities likely have not delayed total net passage time through this reach relative to natural conditions.

The completed dam breach areas would not cause delays of upstream fish migration. The breach areas would be designed to pass fish at flows less than 170,000 cfs, which is equivalent to a 5 year high flow event. For breach areas where velocities are predicted to be above 5 feet per second (ft/sec), at flows less than 170,000 cfs, concrete resting structures would be installed. This would assist fish in migrating upstream in steps, like they would in a normal river rapids area. Flows less than 5 ft/sec are not considered to impede movement and require no additional resting structures (Technical Appendix D, Natural River Drawdown Engineering). While velocities in the breach area at flows greater than 170,000 cfs could be in ranges that may impede movement even with structures, upstream migration does not occur during these high flows (Technical Appendix D, Natural River Drawdown Engineering). The high flow periods occur in the spring when spring chinook salmon, sockeye salmon, and some steelhead pass the lower Snake River.

Several benefits to passage would occur under Alternative 4—Dam Breaching. Fish would not fall back through turbines or over spillways; fallback could cause injuries or contribute to losses between dams. Additionally, although TDG has not been documented in recent years to cause measured mortalities, saturations have been in excess of standards (110 percent) as allowed through water quality waivers obtained by NMFS from state water quality agencies. Without spill through dams, these saturations would be reduced, which would decrease the chance for adverse effects from dissolved gases, especially during very high flows. The PATH group (NMFS, 1998) assumed that the current loss of adult spring/summer chinook salmon migrating upstream through the lower Snake River would decrease from the current estimated value of 15 percent to 3 percent if the dams were breached. However, increases in upstream passage survival may not occur or may be much less than predicted once dams are removed. NMFS (1999b) indicated that limited historical data did not show differences between current (all four dams in place) and historical passage survival prior to the construction of the lower Snake River dams. Gains or losses for other adult anadromous stocks have not been estimated by PATH or others.

Temperature

The effects of temperature changes on adult migration following dam breaching are not clear. This is partly because predictions of future temperatures vary (Technical Appendix C, Water Quality; Yearsley, 1999; Perkins and Richmond, 1999). If lower temperatures (i.e., a general reduction of temperatures greater than 68°F) were to occur overall, as predicted by Yearsley (1999), conditions for upstream migration would be improved for summer and early fall adult migrants, which primarily include late summer and fall chinook salmon and steelhead. However, the overall average temperature change (for days over 68°F) is predicted to be relatively small at about 1.1°F above current conditions at Ice Harbor, although the frequency of maximum temperatures would be reduced. In contrast to Yearsley's (1999) conclusions and the Perkins and Richmond (1999) model, the Corps' temperature model (Technical Appendix C, Water Quality) predicts that during low flow years, temperatures near the mouth of the Snake River would actually be higher if the dams were breached than they would be under

current conditions. This could be detrimental to upstream migration. However, flow augmentation would continue in the summer to supply flow needs in the Columbia River. This could aid in offsetting higher water temperatures in the lower Snake River, if augmentation flows originated from cool water releases from Dworshak Reservoir. The flow releases from Dworshak in the summer would have a greater effect on temperature in the lower Snake River than they currently do because of the reduced water volume in a river compared to reservoirs. In addition, temperatures would likely decrease at a faster rate in the fall, which should benefit later migrating fall chinook salmon and steelhead.

Dissolved Gas Supersaturation

Periods of adverse effects of elevated dissolved gas on adults within the Snake River reach would be reduced under this alternative relative to all others. Although some spill from upstream dams could increase gas saturation, it should still result in TDG concentrations of less than 110 percent near the Snake River mouth, even during high flow periods. The lack of spill, and possibly reduced gas levels, could increase survival of adults during passage through this reach during high flow years and likely reduce headburn injuries which have been associated with high flow conditions or spillway discharges from dams (Elston, 1996). Headburns, however, have not been directly tied to elevated gas levels or gas bubble disease signs (Elston, 1996) and may be from contact and abrasion from dam structures. However, fish would still encounter dam structures, elevated gas saturation, and high spill in the lower Columbia River during high flow years.

Spawning Habitat

Potential spawning habitat within the lower Snake River would increase with dam breaching. It has been estimated that about 23 to 24 percent of the 140 miles of the lower Snake River formerly under reservoirs ultimately would have habitat suitable for spawning based on reconstruction of the channel geomorphology using 1934 sounding data. About 20 percent of the estimated spawning habitat is located from Lower Monumental Dam upstream to the confluence of the Snake and Clearwater rivers. The functionality of this habitat until sediment budget equilibration/pseudo-stabilization can occur is likely 10 to 20 years without active periodic manipulation of flow release greater than 200 kcfs to scour fines out of gravel/cobbles (Hanrahan et al., 1999). Fall chinook salmon would be the primary anadromous salmonid using the newly available spawning habitat in the lower Snake River because they are typically the only anadromous salmon or steelhead species in this region that use large mainstem areas. However, the gain in spawning habitat, relative to historic levels, would still be slight. Most of the historical fall chinook salmon spawning habitat is upstream of Hells Canyon Dam, which is not currently accessible to fall chinook salmon.

The timeframe for actual use of the new spawning areas can not be predicted. However, studies from the Hanford Reach, Deschutes River, and portions of the lower Columbia River (near Pierce/Ives Island) indicate that fall chinook salmon would establish in regions where suitable spawning habitat and adjacent suitable rearing habitat are available (USFWS, 1998a). The fish that would use new spawning habitat in the lower Snake River may be those originating from the upper Snake River or Lyons Ferry Hatchery, both of which are considered part of the current Snake River fall chinook

salmon ESU. However, stray fall chinook salmon from other regions and particularly other hatcheries have been common and often abundant in the past, passing one or more of the lower Snake River dams (Waples et al., 1991; Mendel et al., 1993; Mendel and Milks, 1997; Myers et al., 1998). There is the possibility that these fish may also spawn in the newly developed spawning habitat, which would be concentrated in the lower two reservoirs areas (Ice Harbor and Lower Monumental). The result could be development of fall chinook salmon runs in the Snake River, not of the Snake River fall chinook salmon ESU origin, or possibly the loss of the genetic integrity of the whole Snake River fall chinook salmon ESU.

Water temperature changes in the system under Alternative 4—Dam Breaching would affect both migration into the lower Snake River and the timing of spawning by fall chinook salmon. As previously discussed, it is unclear if summer water temperatures, which at times are currently too warm to permit favorable passage conditions, would change (Technical Appendix C, Water Quality). However, it is likely that late summer and fall water temperatures under Alternative 4—Dam Breaching would decrease more rapidly than under Alternatives 1, 2, or 3. This should benefit upstream migrating fall chinook salmon and steelhead. Releases of cool water from Dworshak during the summer could be used to aid cooling in the lower Snake River, but this is a secondary benefit for enhancement of adult passage. The Technical Management Team process (see Section 1, Introduction) allows for the use of this water for the benefits of adult fall chinook salmon, and some members of the Technical Management Team have regularly requested release of this water in August and early September to improve adult passage. As noted earlier (see Alternative 1—Existing Conditions, Adult–Temperature), the actual allocation of this water has varied demands and may not be used for this purpose. The cooler fall temperatures that would occur without reservoirs could allow fall chinook salmon spawning to begin sooner than under current conditions.

Effects on Other Columbia River Anadromous Salmonids Including Federally Listed and Candidate Species

Juvenile Salmonid Rearing and Migratory Habitat

Without reservoirs upstream to cause settling, substrate and fines from the Snake River would move into the Columbia River below the mouth of the Snake River. The primary effect would be to increase turbidity during periods of high flow, such as in the spring. The increased turbidity should remain below concentrations considered harmful for relatively short periods (e.g., 25 mg/l for less than a week) (Newcombe and Jensen, 1996), which would be more typical of what is present upstream of Lower Granite.

Increased turbidity could help reduce fish and bird predation on outmigrating juvenile fish, likely spring chinook salmon and steelhead, which are most abundant during high spring flows. These benefits would diminish below McNary Dam, because fine sediment settles out. The increased sediment, however, could have some adverse effect to local benthic and possibly primary production in McNary Reservoir. These effects include local burial of benthic organisms from sediment movement into the reservoir and reduced light penetration from turbidity. These effects could reduce local food supplies for juveniles, but should result in only minor effects for migrating fish, which only spend a brief period in the McNary Reservoir during downstream migration. Reduced TDG

saturation in water leaving the Snake River, which often has been greater than 120 percent in the spring, could decrease effects on migrating juveniles in the McNary pool and further downstream. Effects from lower river dams on gas saturation would remain.

Adult Salmonid Upstream Passage

Under Alternative 4—Dam Breaching, any long-term effects to adult salmon and steelhead in the Columbia River would be minor after the long-term, post equilibration which could take from 5 to 20 years. Suspended sediment concentrations should not interfere with upstream migration after possibly 1 to 2 years after final dam breaching. Snake River water temperatures could differ from current temperatures with reservoirs in place, possibly decreasing, at least in the late summer and fall. Any temperature changes in Snake River water would be relatively slight and their effects would be diluted by greater flow in the Columbia River. Therefore, any temperature changes should have only slight positive to no effects on adult migration within the Columbia River. Reductions in TDG supersaturation could also benefit migrating adult salmon and steelhead, particularly spring and summer chinook salmon and sockeye salmon that use the McNary pool and areas downstream.

Summary of Effects to Columbia River Federally Listed Anadromous Salmonids

Of the listed or candidate species within the Columbia River System, exclusive of those from the Snake River, some minor benefits would occur to those fish originating in the upper Columbia, (e.g., upper Columbia River spring chinook salmon, upper Columbia River steelhead). The types of benefits are discussed in the previous section and include possible reductions in predation on juveniles due to increased turbidity, lesser effects of TDG supersaturation, and possible lower water temperature during adult migration. Effects on listed and candidate fish ESUs in the middle and lower Columbia River would be minor to non-existent because any incremental changes in turbidity, temperature, and dissolved gas resulting from the dam breaching operations would diminish below McNary Dam.

Other Anadromous Stocks

American Shad

Overall, the Columbia River System population of American shad should not be noticeably changed over the long term as a result of Alternative 4—Dam Breaching. However, the Snake River population segment is likely to be reduced. Because shad production in the Snake River is a small portion of total production in the Columbia River System (less than 10 percent based on escapement), any changes in the Snake River populations would have no significant effects on system production. Although this species, in its native east coast environment, uses rivers for spawning and early rearing, in the Columbia River System it appears to most successfully use reservoirs for these functions. This suggests that American shad production in the Snake River would decrease under Alternative 4—Dam Breaching. Changes in the Columbia River (e.g., turbidity, temperature, dissolved gas) from changes in the Snake River are not likely to influence overall American shad survival or production in the system.

Pacific Lamprey

The removal of dams and formation of a near-natural elevation river environment could improve Pacific lamprey production for the Snake River. Dam removal should enhance downstream passage survival for juveniles as they would no longer be impinged on screens or suffer mortality as a result of passage through turbines in this river reach. However, these potential effects could continue to exist at the four lower Columbia River dams.

The long-term effects of increased water velocities on migrations in the lower Snake River as a result of dam breaching is unknown, but could be beneficial if fish depend on velocity for movement downstream. While major spawning appears to occur in tributaries, the development of riverine conditions could allow the use of the lower Snake River for adult spawning and juvenile rearing in shallow fine sediment areas of the river. Adult passage could also improve as a result of dam breaching.

Lyons Ferry Hatchery

Dam breaching actions could interrupt, disable, or reduce the use of the Lyons Ferry Hatchery. This hatchery is located on Lower Monumental Reservoir. The hatchery is used for spawning and rearing of Snake River fall chinook salmon, spring chinook salmon, steelhead, and rainbow trout. The fall chinook salmon operations provide pre-smolt chinook salmon stock to Tribal acclimation facilities in the unimpounded Snake River above Lower Granite Reservoir. The water supply depends on eight wells located 2 miles upstream. The water supply pipeline is on piers under the reservoir. There is the possibility that once the reservoir is removed, the loss of the buoyancy supplied by the water may result in pipeline damage or collapse. Also, the current wells would supply reduced volumes or no water to the hatchery because of the reduced head level in the wells following drawdown. This may require new water wells to maintain current hatchery needs. The suitability of water quality (e.g., temperature) for hatchery needs of any new well is unknown. The adult fish ladder access would also need to be modified or extended because its current entrance would be about 60 vertical feet above the new river shoreline.

5.4.1.5 Model Analysis of All Alternatives

This section presents the results of the quantitative assessment of the effectiveness of each alternative relative to the survival and recovery of listed Snake River anadromous fish stocks. It does not address effects to any other Snake River or Columbia River anadromous fish. This assessment is based on the NMFS evaluation of the alternatives as presented in Technical Appendix A, Anadromous Fish. The NMFS assessment relied extensively on the synthesis and analysis conducted in the process known as PATH. While this analysis relies extensively on the PATH results, NMFS developed additional analysis and provided its independent review and interpretation of the results from the PATH analysis as they pertain to the Snake River anadromous salmonid species and alternatives being evaluated.

Additionally, due to some limitation of the PATH analysis (see Subsection 5.4.1.6), NMFS developed a Cumulative Risk Analysis. This analysis is complementary to that done by PATH and is referred to as the Cumulative Risk Initiative (CRI analysis). The CRI is intended to more directly address the chance of extinction of stocks among the alternatives. Risk of extinction is not directly assessed in the PATH analysis. PATH only addressed the effect of hydrosystem. The CRI addressed how alterations in risk factors in addition to hydrosystem—such as harvest and habitat—may affect survival, recovery, and extinction either in conjunction with or independent of operations of the hydrosystem.

A major portion of the NMFS analysis is a salmon lifecycle model developed by PATH that imposes a variety of measures and assumed historic and future survival factors for each alternative (see Marmorek et al., 1998a for specific details of PATH analysis of alternatives). NMFS considered the most recent passage survival research (PIT-tag detection probabilities) against historical conditions and survival estimates to evaluate the validity of assumptions and level of uncertainty of the results of the model for two Snake River species—spring/summer chinook salmon and fall chinook salmon—that were modeled by PATH. NMFS then used this information to develop likely effects for each alternative and project them into the future. NMFS' evaluation placed more emphasis on empirical measures from recent (post-1991 ESA listing) research because the structural configuration and operation of the dams have substantially changed since the 1970s retrospective reference time series used by PATH.

Conclusions about these two fish species, and other literature, were used by NMFS to project likely effects for Snake River sockeye salmon and steelhead, which could not be modeled in the same fashion as spring/summer and fall chinook salmon due to insufficient data. Analysis of the effects of the critical assumptions or values used were evaluated (e.g., delayed transport mortality) to help interpret the meaning of the results of the models.

NMFS defined the five steps used by PATH in their analysis as:

- *"Specifying an array of assumptions and uncertainties based on historical data;*
- *Embedding the above assumptions in models that project futures under different management options and scenarios;*

- *Summarizing these predictions of "potential futures" in terms of the likelihood of meeting survival and recovery criteria (i.e., populations are intended to be above minimum abundance levels [survival] and to even increase to higher abundance levels [recovery]);*
- *Identifying the critical uncertainties that have the greatest impact on the predictions; and*
- *Synthesizing the results and sensitivity analyses into summary statements about the biological merits of alternative management options."*

The CRI analysis will be discussed following the PATH analysis subsection. Details of the methods and performance measures used for the CRI analysis are presented in Section 5.4.1.6, Cumulative Risk Analysis.

Methods and Performance Measures from PATH Analysis

Since the NMFS use of the PATH analysis is key to the overall assessment of the four alternatives, it is important to define briefly important components of the PATH analysis that affect the results. The process includes detailed lifecycle models to predict future chinook salmon populations under a variety of management alternatives. The details of how the PATH analysis conducted the model analysis include a high number of individual computer runs. These runs each had 8 to 10 different key assumptions (e.g., rates of survival at various locations). In general, because of natural variability, the analysis for each alternative would require literally thousands of replicate model runs to develop an outcome. Because of the many varied assumptions used in the analysis and wide range of results, the PATH process assembled a group of four experts (called the Science Review Panel [SRP]) to "weigh" seven key assumption values that are included in the lifecycle models (Marmorek and Peters, 1998a). PATH comparisons of the SRP weighting and equal weighting showed little difference in outcomes, suggesting no reduction in uncertainty for the seven key assumptions other than the 50:50 chance. NMFS, however, decided not to use these weighted results in their analysis for three reasons (Technical Appendix A, Anadromous Fish): *"(1) clarity, (2) using the weighted assumptions does not qualitatively alter any of the conclusions (Marmorek et al., 1998a), and (3) new data render some of the weightings obsolete."*

The performance measures used by NMFS for evaluating the alternatives used in Technical Appendix A, Anadromous Fish are based partly on the NMFS 1995 Biological Opinion, as interpreted by PATH. The measures used by PATH defined the criteria for the survival and recovery of Snake River listed stocks. The details of what is considered to be meeting "survival" and "recovery" criteria are defined in detail in the Technical Appendix A, Anadromous Fish.

For spring/summer chinook salmon, the modeled estimates of the number of fish returning to the spawning stream of origin were used to determine the "survival" and "recovery" criteria. The criteria used for "survival" was that 6 of the 7 index stocks would have estimates of escapement of at least 150 to 300 fish (depending on index stock) in the model runs. The NMFS "survival" criteria would be met if six of the seven index stocks met their survival escapement levels for at least 70 percent of the model assumption sets. The survival periods examined were for 24 and 100 years.

The "recovery" criteria were for these same index stocks to have escapement equal to 60 percent of the average spawner counts from before the 1971 brood year. For "recovery", this escapement was to be achieved for six of the seven index stocks in the last 8 years of a 48-year simulation period. "Recovery" criteria selected by NMFS were for at least 50 percent of the model assumption sets to achieve this escapement. The percent frequency of each of the alternatives meeting these two criteria was determined by PATH.

Methods used to estimate "survival" and "recovery" levels were similar for fall chinook salmon, except only one stock is present—those fish that spawn primarily in the mainstem Snake River upstream of Lower Granite Dam. The "survival" number of fall chinook salmon spawners used was 300 fish, while "recovery" escapement level used was 2,500 fish. Survival criteria were analyzed for modeled periods of 24 and 100 years, and recovery 24 and 48 years after a specific alternative is implemented.

Although the PATH analysis used four criteria (24 and 100 years for survival, and 24 and 48 years for recovery), NMFS selected only the 24-year survival and 48-year recovery criteria to compare the alternatives. The reasons for these selections were (Technical Appendix A, Anadromous Fish):

- *"The 48-year recovery criterion is the criterion that provides the greatest distinction among management actions.*
- *The 24-year survival criterion is the shortest time scale over which any quantitative analyses were performed. Thus, the survival criterion can help measure short term risks."*

NMFS evaluated how closely the alternatives met the criteria in the Biological Opinion by determining the fraction of simulations that satisfied the survival and recovery criterion across all assumption sets for a specific alternative. NMFS does not consider this determination properly termed "true probability" or "average probability" as used by PATH in their documents (Marmorek et al., 1998a; Technical Appendix A, Anadromous Fish). The result is that the probability, as determined by PATH, does not represent the "true probability" intended when making a jeopardy decision. NMFS emphasized, "*The predictions generated by the PATH analyses do not provide absolute predictions and should not be misinterpreted as such.*"

PATH results also indicate which management options (alternatives) are most robust (i.e., those alternatives that achieve the greatest portion of computer runs meeting the criteria under all assumptions analyzed). For example, if an alternative had 100 percent of the runs meeting the criteria, it would be considered better than one that met the criteria in only 60 percent of the runs, if it was believed that all assumptions included had equal weight.

NMFS examined the effects to the listed species of seven alternatives as shown in Technical Appendix A, Anadromous Fish. This examination was based on PATH results. Only four of these alternatives are included in the following text. For various reasons (see Section 3), the three other alternatives were not considered suitable for detailed evaluation in this FR/EIS. The four alternatives included in the text are those presented throughout this FR/EIS.

The analysis presented by NMFS also considered a variety of factors that affect the lower Snake River stocks including: population dynamics, direct and indirect effects on juveniles and adults, climate, harvest, hatcheries, and habitat. As noted above, the Cumulative Risk Analysis subsection (5.4.1.6) conducts a quantitative analysis of potential cumulative effects of factors other than the hydrosystem. Other than this subsection, the analysis summarized in this FR/EIS is limited to the discussion of those factors in the hydrosystem that affect the overall survival and recovery of listed species.

Key Issues

The survival of salmon, as indicated by the smolt-to-adult ratio (SAR), has decreased dramatically from the period prior to 1970. However, there are many factors that appear to correlate with this decline. These have included such factors as increased number of dams, increased number of hatchery releases, and changes in ocean conditions. The similar trends among many factors make it difficult to determine the exact cause or "blame" for the decline. Additionally, it is unlikely that any one factor, either natural or human-induced, can be assigned the total blame for the decline. The current populations of salmon and steelhead in the Snake River are likely the result of many combined factors (NRC, 1996).

There are several key technical issues that affect both the analysis and interpretation of the results that are discussed in the following sections. Because the data available cannot definitively determine how certain factors affect survival, observed changes in past survival have become open to interpretation. However, as more data are gathered, the interpretation of the observed changes may be narrowed. The key factors that had major effects on both how the PATH analysis was conducted and the meaning of the results include:

- Differential Delayed Transport Mortality
- "Extra Mortality" and its sources
- Return to Natural River.

Each of these factors is summarized below.

Differential Delayed Transport Mortality

Differential delayed transport mortality is the assumed additional mortality transported juvenile fish suffer relative to those fish that have survived passage of the dams and reservoirs. This component has a large effect on estimates of juvenile fish survival in the Snake River System because upwards of 50 to 60 percent of spring/summer chinook salmon, and a similar portion of steelhead, have been transported to below Bonneville Dam in recent years.

Differential delayed transport mortality is not actually measured, but is an estimated value based on other measurements and assumptions. If the delayed mortality is the direct result of activities associated with the hydrosystem, then modifying or removing these activities would eliminate this source of mortality. However, if the assumptions used to estimate differential delayed transport mortality are wrong or the source of the additional mortality is caused by something other than activities associated with the

hydrosystem, then modifications would not eliminate this mortality factor. For example, if fish suffer additional mortality from disease (not caused by the hydrosystem), breaching of dams or cessation of transport would not affect overall survival.

Estimates of differential delayed transport mortality have been made based upon transport study estimates of TIRs, in-river survivals and SARs for over two decades. There are differing scientific opinions about which estimates of this mortality should be given most credence in determining future conditions for each alternative, especially for Alternative 4—Dam Breaching.

The parameter used to delineate the effects of delayed transport mortality is the "D-value." This value is the ratio of survival of transported fish to below Bonneville Dam to that of surviving untransported fish. If D=1, there would be no differential delayed transport mortality, while values less than 1 would mean that released transported fish survive at a lower rate than untransported surviving fish. For example, when D=0.33, the estimated survival of transported fish is only one-third that of surviving untransported fish.

Extra Mortality

Another important concept is "extra mortality." While many stocks in the Northwest, including the middle Columbia River, have declined since the late 1970s, those from the Snake River have suffered greater mortality, as measured by the SAR, even considering measurable hydrosystem and other effects. The extra mortality is essentially the remaining additional mortality that needs to be added to the models to obtain the observed SAR values after all other measured and estimated values are included. There are generally three possible sources hypothesized for this extra mortality: hydrosystem, ocean/climate regime shift, and stock viability degradation. These are discussed below.

Hydrosystem

Extra mortality from the hydrosystem would be considered mortalities that are in addition to those already included in the models (e.g., direct hydrosystem mortality, dam and reservoir passage mortality, and delayed transportation mortality), but are secondary effects unique to the Snake River stocks as a result of changes caused by the hydrosystem. Examples of this type of mortality could be changes in flow that affect the estuary, thus reducing its suitability for Snake River stocks, changes in arrival timing of the stocks to the estuary, and additional disease or susceptibility to predation due to worsened conditions following migration through the Columbia-Snake River System. Although data are not available to quantify that hydrosystems have had additional effects to survival, the fact that large physical and biological changes have occurred to the Columbia River System as a result of the hydrosystem is well documented (Williams et al., 1999). While many plausible mechanisms are available to suggest that some form of extra mortality may be occurring as result of the hydrosystem, they are just experimentally difficult or impossible to measure. Consequently, less direct statistical analyses are the primary means of evaluating whether the hydrosystem causes appreciable mortality or reduced fitness to fish below Bonneville Dam.

Ocean/Climatic Regime Shift

Extra mortality could also result from changes in the ocean conditions that have uniquely affected Snake River stocks differently than other Columbia River stocks. There is a large volume of scientific information that has indicated which changes in ocean conditions have affected many coastal stocks. Examples include El Niño, which occurs over several years, and the Pacific Decadal Oscillation (PDO) that occurs over decades. Most of the information that has actually documented these effects is for Alaskan and Canadian salmon stocks; there is minimal information on Snake River stocks. Some of the changes in ocean conditions known as the PDO Index, have occurred over the 1977 to 1986 period, which corresponds to the onset of low SARs of many salmon stocks (not just Snake River stocks). The theory behind the PDO suggests that when the ocean cycle becomes more favorable, smolt-to-adult values would also increase. However, for this theory to apply to the conditions in the Snake River, the effects of ocean conditions would need to have a much greater effect on these stocks than on similar life history stocks of the lower Columbia River, which have not shown the same relative decrease in survival (Schaller et al., 1999).

Stock Viability Degradation

This is primarily referred to in the PATH analysis as the BKD factor. Mortalities attributed to this factor would suggest that Snake River stocks have acquired increased BKD infections in more recent times. However, in the model, this factor really includes a wide variety of non hydrosystem or ocean-induced effects such as genetic effects due to hatcheries, species competition, and predation on juveniles by Caspian terns. If stock viability degradation is valid, then it is likely that none of the alternatives would eliminate this factor.

Natural River

The general concept of a "natural river" is not specifically addressed in PATH modeling. The PATH process and NMFS CRI analysis have generally used quantitative models to predict the effects of the alternatives considered. These analyses use lifecycle conditions that can be measured or predicted/estimated from data.

While the concept of "natural river" conditions is sound, the difficulty is in determining what components of the natural river are the more important ones relative to the recovery of the stocks of interest. Since so many changes have occurred in the Columbia-Snake River System in over a century of development, achieving a true natural river is not possible. With these changes, it is essential to know which ones are important. NMFS takes the position that any proposed changes must be linked to measurable improvements in salmon survival or productivity. The reason for this is that conditions that "look like a natural river" could not produce the desired result because they do not include, or because they ignore, the many other factors that affect fish survival.

Individual Snake River ESU Model Analysis

The following sections present the results of NMFS' analysis of hydrosystem alternatives for each Snake River ESU. The CRI analysis follows in a separate

subsection (5.4.1.6) addressing the extinction potential and potential effects of other actions to these ESUs. The level of analysis varies markedly by individual ESU so that the type of analysis is not consistent among the ESUs. The order of presentation is from most to least available information to conduct a quantitative analysis. Spring/summer chinook salmon are discussed first. Information was available for this ESU to conduct a fairly thorough analysis because more data are available and the PATH group has directed greater effort at this ESU. This stock is assessed against specific recovery criteria in a quantitative manner. Although fall chinook salmon was analyzed in a similar quantitative manner as spring/summer chinook salmon, the analysis is very preliminary. This is because there are much less data available on this stock because of relatively few site-specific studies on downstream passage survival and transportation survival, and because much less effort has been directed at this ESU by the PATH group than spring/summer chinook salmon. Steelhead results are presented next, and there is even less information to develop quantitative results. The lack of escapement data for this stock has limited the ability of modelers to develop a full lifecycle model like they did for spring/summer chinook salmon. The analysis of sockeye salmon is really not quantitative in the same manner as the other three ESUs. This is because so few fish have been in the system for many years, so it is difficult to develop background information to conduct a similar analysis.

Snake River Spring/Summer Chinook Salmon

Several factors both within and outside of the hydrosystem affect spring/summer chinook salmon survival. Habitat, hatcheries, harvest, and hydropower are commonly described as factors that affect the survival of these fish. NMFS provides a summary of many of the effects (Technical Appendix A, Anadromous Fish), both current and historical, of habitat, hatcheries, and harvest on Snake River spring/summer chinook salmon and additional information on important life history stages (e.g., egg-to-smolt). This information will not be repeated here.

This section concentrates on two major areas. First, the survival factors and hypothesis that influence predications of the PATH assessment of alternatives are summarized. Second, a discussion of the major assumptions used in the analysis methods and the results of the PATH analysis are presented with a discussion of the influences that critical assumptions have on predictions involving the success of the alternatives in meeting the NMFS criteria. Available information for analysis is greatest for spring/summer chinook salmon, allowing greater detail in the analysis of this ESU relative to other Snake River anadromous fish species.

Survival Factors

The parameters that affect the smolt-to-adult life stage are the major ones addressed in the PATH analysis. The PATH process separates this life stage into two parts: 1) direct survival of outmigrating juveniles from the head of the hydrosystem (i.e., Lower Granite Reservoir) to below Bonneville Dam and, 2) survival from below Bonneville Dam until fish return as adults to their natal streams. While the rate of survival of adults during upstream migration past dams does influence populations, it has been determined fairly accurately from tagging studies. These values are within the range (21 percent and

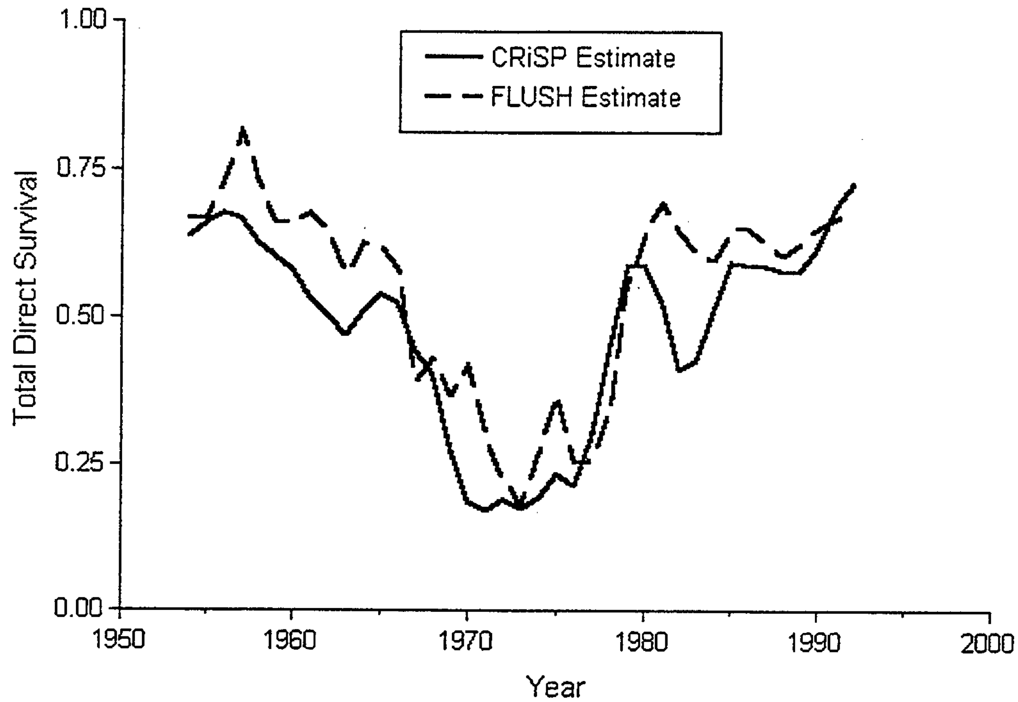
50 percent) used in the lifecycle model and will not be discussed further. Once PIT-tag detectors for adults are installed between Lower Granite and Bonneville, estimates will be more precise than the adjusted dam count data used in the past. Likewise, information on the survival of juvenile fish traveling downriver through the lower Snake River hydrosystem is moderately good, mainly as a results of better estimates made possible by PIT-tag technology. More detection in the lower Snake River would aid in predicting survival for the entire hydrosystem. Therefore, the major unknown survival factor involves the estuaries and oceans. Even though information could be substantial for either upstream or downstream migrating fish, there still remains uncertainty in the precision of the estimates of survival and causes or mechanisms of mortality throughout all phases of the smolt-to-adult life stage, as will be discussed in the following subsections.

Direct Survival to Below Bonneville Dam

The main method of estimating downstream passage survival has been by the use of models. PATH used two different passage models, CRiSP and FLUSH, to develop these estimates (Beamesderfer et al., 1998; Marmorek et al., 1998a). Historically, the estimates of survival that were entered into these models were based on mass visual marking studies. These were often done over limited reaches of the river and extrapolated to the whole reach from Lower Granite Reservoir to Bonneville Dam.

More recently, survival estimates have been based on PIT tag studies. These internal tags are used to identify individual fish without the need to remove the tag (i.e., the fish can be identified, but does not need to be sacrificed). In recent years, PIT-tag detecting has been expanded to Bonneville Dam. Additional PIT tag detectors were used in trawls in the lower river to augment data collections on passage survival. This has reduced some of the uncertainty in modeling portions of the down-river passage stage, especially the lower Snake River dams. Each of the two passage models uses run reconstruction information (Beamesderfer et al., 1998; Marmorek et al., 1998a) and makes assumptions about passage survival at each dam and reservoir. The details of each of these models are presented in PATH reports (Marmorek and Peters, 1998b; Marmorek et al., 1998a).

Although the passage models differ in their approach to determining reservoir mortality, they generally agree on the dam survival contribution to total direct survival for juvenile fish migrating from Lower Granite Reservoir to below Bonneville Dam. The historical passage survival estimates by the CRiSP and FLUSH models are shown in Figure 5.4-2. The fact that the SAR values have not paralleled those of the direct passage survivals suggests some other additional factors (e.g., ocean conditions, delayed transport mortality) are contributing to the continued low SARs. The two models differ on what delayed transport survival is (i.e., the effective D-value), resulting in differences in their estimates of overall survival through the hydrosystem. The uncertainty of D-values will be the focus of much of the later discussion in this section because these values are one of the more important components in determining the differences among alternatives.



Note: Direct survival does not account for any delayed mortality of either transported or in-river migrants.

Figure 5.4-2. Total Direct Survival (Transported plus In-River Migrants) of Juvenile Spring/Summer Chinook Salmon to Below Bonneville Dam, Graphed as 5-year Moving Averages

Ocean and Climatic Effects

Ocean and climatic conditions play a major role in salmonid survival. Noticeable changes in Alaska and British Columbia stocks have shown shifts in abundance beginning in the late 1970s in response to ocean changes that are apparently on an approximate periodic 30-year cycle (Mantau et al., 1997). However, the specific relationship to Snake River spring/summer chinook salmon stocks is unclear with statistical correlations between survival of Columbia River Basin stocks and ocean conditions being weak (Marmorek et al., 1998a). The change in ocean and many climatic conditions of the late 1960s and early 1970s coincided with a downward trend in survival of spring/summer chinook salmon, both in the Snake River stocks and other stocks farther downriver.

Because of the uncertainty of the relationship of ocean conditions to Columbia River spring chinook salmon stocks in general, and to Snake River spring chinook salmon stocks in particular, PATH made two assumptions in their model analysis. One assumption was that ocean conditions affected the lower river and Snake River spring/summer chinook salmon stocks in a similar fashion, while the other assumption was that ocean conditions had a disproportionately greater effect on Snake River stocks. The PATH analysis of historical smolt-to-adult return data supported the former assumption because it appeared that ocean conditions had similar effects on Snake River spring/summer chinook salmon as they did on those spring chinook salmon originating in lower river tributaries. However, some returns of West Pacific coho salmon and steelhead stocks (not of Snake River origin) had sharp declines in 1992 and 1993 that were similar to declines in Snake River spring/summer chinook salmon. This similarity lead to consideration by PATH that ocean conditions could disproportionally affect Snake River spring/summer chinook salmon if they were being affected in a similar manner as these coho salmon and steelhead stocks. This consideration was analyzed separately for the alternatives.

There are two views on the effects of ocean conditions and climate on the Snake River salmon runs. Some members of the PATH group believe available information suggest that the hydropower system and fish transportation are overriding factors affecting survival and the return of adult salmon from the ocean. Some other scientists, both within and outside of the PATH group, have contended that the effect of ocean conditions and climate are so overriding in the return of adult salmon that no matter how hydropower effects were diminished, or how successful the juvenile fish transportation program is, the runs would still be in dire condition.

Anderson (1998) reviewed the effects of hydropower development, harvest, and ocean/climatic conditions on the oscillation of Columbia River salmon runs. Anderson concluded that ocean/climate conditions, the Pacific Northwest Index (PNI) described by Ebbesmeyer and Strickland (1995), explained some of the previously unexplained fluctuations in salmon abundance and harvest. Anderson also concluded that the decline in salmon harvest in 1920 coincided with a switch in the PNI from a cool/wet regime to a warm/dry regime. The development of the hydropower system in the 1940s through 1975 coincided with the switch from a warm/dry regime to a cool/wet regime, so the impacts to fisheries were masked to some degree by higher returns. After the dams were constructed, Anderson identified a period of run rebuilding efforts (hatchery

construction, development of bypass systems at the dams, and juvenile fish transportation). Anderson stated that, "...the failure of the stocks to increase with the rebuilding efforts of the 1980s... was likely in part the result of unfavorable ocean conditions, which have counteracted improvements in smolt passage survival..."

Anderson's (1998) findings are supported by Hare et al., (1999) who described the PDO. The PDO is described as, "Temporally, both the physical and biological variability are best characterized as alternating 20- to 30-year-long regimes punctuated by abrupt reversals..." Similar to the pattern observed by Anderson, cool/wet cycles were observed to alternate with warm/dry cycles. Production and catch of salmon stocks along the West Coast would be low during warm/dry cycles when ocean conditions were poor, but production and catch of Alaska stocks would be high due to good ocean conditions further north. The converse would be true when cool/wet condition prevailed along the West Coast; ocean production in the northern ocean would be low. Hare et al., (1999) correlated these conditions with salmon harvest, and came up with approximately the same time frames for salmon abundance described by Anderson (1998). They surmised that, "...climatic influences are driving the alternating regimes of salmon production that (they) identified in (their) analysis..." They cautioned that, "...a lack of immediate increases in production following restoration efforts may be misconstrued as management failures in periods of poor ocean conditions."

Taylor and Southards (1997) described a similar pattern for periods from 1896 to 1914 (wet/cool), 1915 to 1946 (dry/warm), 1947 to 1975 (wet/cool), and 1976 to 1994 (dry/warm) and how climate affected West Coast salmon production. Both Taylor and Mantau et al. (1996) reported findings similar to those reported by Anderson (1998) and Hare et al. (1999). Taylor and Southards (1997) described how Columbia River and other West Coast stocks were out of phase with Alaska stocks, and related that finding to the ocean/climate pattern. He went on to say, "While there are undoubtedly human-induced effects on the fish (including dam construction and habitat destruction), natural variability may be a very significant influence as well, and should be considered in any salmon restoration plan..."

Taylor and Southards (1997) went on to say that the rebound resulting from a shift to a cool/wet cycle in 1996 might already be occurring. In 1997, the Oregon Department of Fish and Wildlife reported the second highest chinook salmon redd counts on record since 1959 for the John Day River. In 1999, spring, summer, and fall chinook salmon runs to the Columbia River exceeded fishery agency predictions by substantial margins. More importantly, however, the jack salmon counts were much higher than in recent years. The spring chinook salmon jack count, at 8,900 could predict an adult return of over 200,000 spring chinook salmon in 2000 (compared with 38,000 in 1999) according to the fisheries agencies (*NW Fishletter*, June 2, 1999).

British Columbia fisheries scientists believe that ocean/climate conditions overwhelmingly drive the returns of Pacific salmon to British Columbia streams (Stocker and Peacock, 1998). For most stocks in trouble, the leading cause listed was "...poor marine survival." For some salmon, they concluded that "...stocks are extremely depressed, will continue to decline even in the absence of any fishing mortality and are at immediate risk of biological extinction." Such predictions led to the complete closure of

coho salmon fisheries along the British Columbia coast in 1998, and reduced harvest allowances in 1999.

In 1996, the Northwest Power Planning and Conservation Act of 1980 received its first and only amendment. The Congress instructed the Northwest Power Planning Council (NPPC) to "...consider the impact of ocean conditions on fish and wildlife populations..." in review and implementation of their Columbia Basin Fish and Wildlife Program. In their Ocean Condition Paper (NPPC, 1997), the NPPC noted that, "what is striking, however, is that this ...(information on the ocean and its relationship to salmon production) is not being meaningfully incorporated into Columbia River salmon management..." The NPPC adopted a recommendation to "facilitate integration of information on the ocean environment into Columbia River management.." It also launched a review of existing information and identified the need for further, new information and research to support their Fish and Wildlife Program and related decision making.

In 1999, David Welch, Director of High Seas Research for Canada's Department of Fisheries and Oceans, told a work group sponsored by the BPA how ocean conditions have affected west coast salmon runs. While some runs seemingly did well, others did not. He noted SARs, had declined for several stocks, while others had increased. Steelhead from one river declined from 16 percent to 1 percent; Oregon coho salmon went from 6 percent in 1976 to 0.6 percent in 1991 to 1995 (Welch, 1999). Some members of PATH rely on SARs, which are higher for some stocks (John Day River) and lower for other stocks (Snake River), to demonstrate "extra mortality" from the hydrosystem. Since all stocks migrate to the same ocean, PATH contends, the hydrosystem must be responsible for the difference.

Data collected since 1995 on NMFS weekly release groups of PIT-tagged smolts support the pre-dam lower Snake River observations of Van Hyning (1968) that some chinook salmon are oriented southward by the currents to have their tags recovered in California rivers. Spring chinook salmon SARs for the 1995 outmigration are about 7 times higher for transported smolts that passed the estuary following the second week of May. This date correlates with the spring transition shift of winds and currents in the estuary and near ocean.

Welch (1999) told the same workgroup that poorer ocean conditions off British Columbia have significant effects on Oregon and Washington stocks and huge impacts on juvenile fish. Welch said that efforts to improve habitat (like hydropower bypass improvements) "...are knee-jerk reactions that don't factor in the huge changes that have occurred in the ocean environment..." He said that "...the latest warming of the North Pacific was something that is expected to occur only one in ten thousand years...," and that "...returning salmon (are) smaller in size and have reduced fecundity." He said that "...fish managers are not taking such factors into account when they predict run strengths...because salmon are about half as productive as they used to be..."

While it is clear that there are two schools of thought on the issue of the effects of ocean/climate conditions on the Columbia River salmon runs, it is not clear that all Snake and Columbia river stocks would be affected in the same way, or that the effects of fish transportation or the hydropower system may or may not be overwhelmed by what is happening in the ocean.

Hydrosystem Passage Effects

Differential Delayed Transport Mortality

The PATH analysis used the D-values for its analysis derived from estimates of TIRs from transportation studies, in-river survival, and SARs for the 1970s and 1980s. More recent studies in 1994 and 1995 that were based on PIT-tag detection probabilities, suggested that D-values used in the PATH analysis could be low relative to current conditions (i.e., post Bonneville Dam survival of transported fish, compared to in-river fish, could actually be better than the data used by PATH would indicate). Depending on the statistical methods used, the 1994 group of fish had an estimated D-value of 0.81 (95 percent Confidence Intervals [C.I.] of 0.34-1.51) and the 1995 group, using two different estimating methods, had D-values of 0.91 (95 percent C.I. of 0.71-1.16) and 0.82 (95 percent C.I. of 0.55-1.18).

The D-values used in the PATH model, however, were much lower than these means. The CRiSP mean D-value used was 0.66, while the mean FLUSH values ranged from 0.31 to 0.53. However, it should be noted that the more recent data have wide confidence intervals and only represent 2 years. NMFS scientists believe that the 1994 and 1995 PIT data should be given substantially more weight for prospective modeling into the future than early data because the estimation method using PIT tags is greatly improved and reflects current operation conditions consistent with the 1995 and 1998 Biological Opinions (see Technical Appendix A, Anadromous Fish).

There may be bias in applying some of the PATH-developed D-values to recent and future conditions. The PATH models applied D-values to all transported fish independent of which site they were transported from, even though in more recent years they may have been transported from four different sites. In contrast, historical D-values (before PIT tags) were determined only from fish transported at Lower Granite and Little Goose dams. Data suggest the site from which fish are transported may influence their later survival. In many recent years, fish have been transported from four different dams. The result is that D-values applied in this manner may not be representative of most recent or future conditions. For this reason, NMFS restricted its calculation of D-values to fish transported from Lower Granite and Little Goose dams in recent years. They took this approach to be more consistent with most of the past estimates of D-values, and because the emphasis in the future transport will be mostly from the upper dams (Lower Granite and Little Goose). Methods of how NMFS estimated D-values and survival are presented in various annexes of Technical Appendix A, Anadromous Fish.

Dam Bypass Systems

PIT tag studies were also used to help estimate the effect of dam passage systems on survival of smolts left to pass entirely in-river (NMFS, 1999b). Although sample sizes were small, it appears that the fewer number of times that fish travel through bypass systems at dams, the greater their survival, based on SARs. For wild fish, the SARs were 0.23 percent (15 of 6,544 fish), 0.18 percent (22 of 12,512 fish), 0.13 percent (9 of 6,801 fish), and 0.19 percent (3 of 1,602 fish) respectively, for fish that were detected zero, one, two, or three times after leaving Lower Granite Dam. Sample sizes were small for all of these groups, especially those detected passing three times (three fish) which made the significance of the results questionable (especially for the three group).

Extra Mortality

In essence, extra mortality is the remaining mortality value needed to balance the lifecycle model to the adult escapements of the run reconstructions after all other mortality factors have been estimated. It specifically does not include such factors as direct downstream passage mortality (from passage models), but could include uncertainties or errors in estimates of differential delayed transport mortality. While the cause of this mortality is not known, three factors are considered as possible sources: 1) climatic effects specific to Snake River salmon, 2) other factors known as "stock viability," and 3) delayed hydrosystem effects not accounted for in other estimates.

Ocean/Climate Regime Shift

This hypothesis promotes the idea that during certain cyclic periods of time, ocean changes specifically affect Snake River stocks more adversely than other Columbia Basin stocks and that these conditions change on a cyclic nature of about 10 to 30 years known as "regime shift." These conditions are in addition to ocean conditions that have affected other Columbia River stocks adversely in recent years. Under this hypothesis, conditions have worsened in the ocean for Snake River stocks, beginning in the early 1970s and more specifically measurable beginning in 1977. It is expected that these conditions are cyclic and will return to better conditions in about 2005. The SRP did not give much credence to this as a source of significant "extra mortality" for Snake River stocks (Peters et al.,1998).

Reduced Stock Viability

Loss of stock viability caused by actions other than those directly related to the hydrosystem is another hypothesis considered as a possible source of extra mortality. Several possible sources for reduced stock viability have been considered. The initial potential source was thought to be an increase in the incidence and severity of BKD as a result of increased release of hatchery fish. BKD used as a representative mechanism for the extra mortality is a "here to stay" hypothesis for which hydrosystem improvement would have no/very little effect in reducing extra mortality. This increased incidence could result in increased mortality of juveniles from BKD after they leave the hydrosystem (i.e., below Bonneville Dam).

Another source of reduced stock viability could be potential stress from interactions with hatchery fish, which has been demonstrated with large steelhead smolts under laboratory conditions. Additionally, predation directly by the large number of hatchery fish, such as large steelhead, may be a source of this extra mortality. Also, genetic degradation could also be occurring as a result of hatchery practices. This could result from inbreeding of hatchery fish, or from having too few fish in the gene pool. This represents the hypothesis that a large proportion of extra mortality is in addition to direct dam effects; removal of that effect results in a marked increase in survival with no change in hydrosystem action.

Downstream effects on stock viability include possible changes in flow to the estuary that could affect nearshore production, and increased predation below Bonneville Dam from such sources as birds (e.g., Caspian terns) and marine mammals, which have both been on the increase since the late 1970s (NMFS, 1999d). For example, Caspian terns

have been estimated to consume 5 to 30 million smolts annually (Roby et al., 1998). PIT tags show that the majority of tagged smolts taken near Rice Island are steelhead (up to 20 to 30 percent mortality vs. 0.5 percent mortality for spring chinook salmon for NMFS-tagged fish since 1988 compared to approximately 3 percent mortality for Idaho PIT-tagged fish. There is no estimate for fall chinook salmon).

Hydrosystem

Under this hypothesis, extra mortality of spring/summer chinook salmon is the delayed mortality resulting from fish passing through the four lower Snake River facilities. The general idea is that "extra stress" or a "weakened condition" is reducing survival of fish after they arrive below Bonneville Dam. The rationale for this hypothesis is that the presence of the dams has changed the ecology of the river system, which would be expected to have additional effects on the native migrating fish. These changes would likely not be easily measured directly. If this hypothesis were true, then removal of the Snake River dams would remove this extra mortality component, returning the SAR to the 3 to 5 percent that it was prior to the construction of the four Snake River facilities.

Alternatives Analysis

The PATH process uses the two passage models—CRiSP and FLUSH—to estimate downstream passage survival for multiple aggregate hypothesis representing each alternative. These models also include historical environmental conditions (1977 to 1992) in mathematic representations of critical assumptions and the range of assumptions about juvenile passage conditions for each alternative. Critics of PATH are concerned that reliance on pre-1992 conditions, operations, and survivals does not reflect the marked increase in reach survivals calculated through PIT tag detection probabilities between 1992 and 1998. The median survivals and variability results of these models are entered into the lifecycle models to estimate resulting spawner escapement estimates which are used in the evaluation of whether or not alternatives meet performance criteria established by NMFS for survival and recovery.

PATH Model Assumptions

A variety of assumptions concerning estimates of survival at each fish life stage and passage facility were used in the models. While many assumptions were used in formulating hypotheses, the uncertainties about assumptions for extra mortality calculated as unexplained error by the lifecycle delayed transport mortality, and drawdown (length of transition, equilibrated reach survival, effects of transition) significantly influenced the results.

Dam Passage and Reservoir Survival

The models are partitioned with respect to survival of in-river migrating juvenile fish into two sections per dam. These are: 1) survival values for various routes of dam passage, and 2) survival values for fish migrating through reservoirs. Details describing values are presented in Technical Appendix A, Anadromous Fish.

In general, the estimated distribution of fish by route and assigned survival values for each of those routes were applied to fish and compiled as they passed dams. There was a range of survival values for some routes (turbine survival) and for estimates of proportion of fish passing by each route (FGE).

Survival through the reservoir was addressed differently between CRiSP and FLUSH. The CRiSP model assumed mortality rates based on water temperature and its influence on predator consumption, estimates of travel time, and exposure models of fish to dissolved gas. FLUSH assumed mathematical survival rates for travel time and temperature-driven predation and did not consider water temperature or dissolved gas effects directly. PATH analysis also considered the potential effects of the northern pikeminnow reward removal program, assuming 0 to 25 percent reduction in reservoir predation mortality as the range of effects of this program (NMFS, 1999d).

Transportation and Differential Delayed Transport Mortality

Three sets of assumptions were used for fish where alternatives included fish transport: 1) portion of migrants transported (FGE); 2) direct survival of transported fish while in barges (assumed to be 98 percent for both CRiSP and FLUSH); and 3) delayed transport mortality. The FGE was standardized for each dam depending on flow and spill conditions specific to each alternative. FGE is the same for both passage models.

CRiSP and FLUSH differ significantly in their assumptions about differential delayed transport mortality or D-values (see Marmorek et al., 1998a for details). The models differ in both the way the values were determined and the values that were used in the analysis of future conditions for each alternative. D-values can greatly affect the future projections for each alternative (see Critical Assumptions discussion). For example, if D-values are high, then dam breaching or any in-river passage operation would have a minimal effect on increasing overall survival compared to transport. The implication of these differences is greatest for Alternative 4—Dam Breaching. If D-values are assumed to be close to 1.0, then dam breaching would have little or no benefit on survival compared to Alternative 1—Existing Conditions. However, if D-values are smaller than 1, differences between current conditions with transportation and dam breaching could be large, making drawdown appear much better for increasing survival if uncertainties of drawdown are ignored or assumed negligible. The assumptions about future D-values are one of the major differences between the two passage models.

Drawdown

Breaching of the four lower Snake River dams (Alternative 4—Dam Breaching) assumes conditions partitioned for four periods (Table 5.4-2): 1) pre-removal (prior to commencement of removal), 2) removal (dams actively breached), 3) transition (directly after dam breaching and prior to mostly equilibrated conditions, and 4) equilibrium (after transition). Sensitivity analysis was conducted for the transition period (Marmorek et al., 1998a). Values of 10 percent and 50 percent for in-river survival during this transition period were assumed for the sensitivity analysis. Even with this wide range of values, the resulting estimates of survival and recovery were little affected, indicating that the survivals occurring during the transition period would still have only a minor influence on achieving NMFS performance criteria. However, changing NMFS criteria is highly

influenced by duration of transition. The PATH analysis of Alternative 4—Dam Breaching assumes no additional mortality above current conditions to juvenile or adult salmonids during the removal or transition period.

Table 5.4-2. Summary of Estimates of Duration, Juvenile Survival, and Adult Survival for the Four Time Periods for the Lower Snake River Reach Only

Time Period	Duration (Years)	Juvenile Survival[1/]	Adult Survival[2/]
Preremoval	3 years or 8 years	Determined by passage models	Current estimates
Removal	2 years	No change from preremoval period	No change from preremoval
Transition	2 years or 10 years	Linear increase from preremoval survival to equilibrated survival	Linear increase from preremoval to equilibrated value
Equilibrium	Determined by length of simulation period	0.85[3/] or 0.96[3/]	0.97[3/]

1/ Juvenile survival is calculated over the four Snake River project reaches.

2/ Conversion rates.

3/ Assumed portion of fish surviving passage through the lower Snake River drawdown reach (from Lower Granite through Ice Harbor).

The transition period would have several changes that could affect juvenile survival. The main factors of concern during this period are the effects on predation rate and effects of elevated suspended sediment, including possible contaminants. Several factors are thought to affect predation during transition. Many of these factors would also affect survival after the transition period. With the reduced water volume and area, predator populations could decrease, although some short-term densities could increase. If water temperature were to decrease, then predation rates per predator should also decrease (see Section 5.4.1.4, Alternative 4—Dam Breaching). Increased suspended sediment would also reduce predation by supplying cover for juveniles. The increased suspended sediment, possibly including contaminants, could be directly detrimental to juveniles during migrations, depending upon concentrations and length of exposure (Newcombe and Jensen, 1996) (e.g., reduced feeding success, toxic conditions). Detrimental effects of suspended sediment or contaminants were not considered directly in the models. It is expected that habitat changes under Alternative 4—Dam Breaching would also be less conducive to predators. The reduced travel time of juveniles would result in reduced exposure to predators. However, the limited data available from unimpounded reaches of the Snake and Columbia rivers have not indicated reduction in predation rates in rivers relative to the main reservoir bodies (Petersen and Poe, 1998; Petersen et al., 1999; Nelle, 1999).

Projected Juvenile Survival

The combined effects of all in-river and transport survival factors were used by PATH to estimate overall juvenile survival for each alternative. Two types of estimates of

survival were made. These were termed "total direct survival" and "system survival." Total direct survival is the cumulation of all estimated survival factors for in-river and transported fish to below Bonneville Dam, without consideration of possible delayed mortality of transported fish. System survival includes the estimates of differential delayed mortality (i.e., D-values).

For both CRiSP and FLUSH models, Alternatives 1, 2, and 3 have higher total direct survival than Alternative 4—Dam Breaching, primarily because of the high portion of fish transported which have a directly estimated survival value of 98 percent. However, with the inclusion of the estimated D-values, which differ between the CRiSP and FLUSH models, the results for Alternative 4—Dam Breaching have a higher system survival than the other alternatives (for both models). The use of different D-values between the CRiSP and FLUSH models account for almost all of the differences in survival between the two models (Appendix D of Marmorek and Peters, 1998a).

Lifecycle Modeling

PATH used a lifecycle model to estimate the number of adult spawners for each of the seven index stream stocks of spring/summer chinook salmon (see Technical Appendix A, Anadromous Fish). This model was structured to allow the incorporation of different assumptions about each alternative, sources of extra mortality, and passage models (CRiSP and FLUSH) (see Technical Appendix A, Anadromous Fish for details). The two ways of dealing with extra mortality in the lifecycle model were referred to as Alpha and Delta. The Alpha approach assumes that each of the seven index spring/summer chinook salmon stocks responds separately to changes in ocean conditions and climate and from reference lower Columbia River stocks with fewer dams to pass. Variations in climate/environmental factors are incorporated into this approach. The Delta approach assumes that there are common year effects of the ocean conditions and climate that affect lower Columbia River and Snake River stocks of similar life history in the same fashion. The Delta approach adjusts for these similar reactions in forward projects based on data from the 1952 to 1989 period. Sensitivity analysis, however, found that the approach chosen (Alpha or Delta) had little effect on estimates of adult spawners for any of the alternatives.

PATH Results for Spring/Summer Chinook Salmon

The results presented in this section are a summary of how NMFS interpreted the results of several PATH reports. It is important to note that only Alternatives 1 through 4 are discussed. Other alternatives and potential effects from other factors such as hatchery release, harvest, or habitat conditions were not directly evaluated.

One way to evaluate alternatives is to determine how robust the alternative is. The alternatives that meet the survival and recovery benchmarks under the largest number of assumptions would be considered the most robust. The results of a particular combination of alternative assumptions are expressed as the fraction of model runs exceeding the survival or recovery threshold number of spawners through time under that set of assumptions. PATH evaluated uncertainty in the models by running 4,000 100-year replicate Monte Carlo simulations for each assumption set. The result is the fraction of model runs exceeding the specific NMFS survival and recovery escapement criteria.

Based on the robustness of the results, Alternative 4—Dam Breaching exceeds the other alternatives in meeting recovery population escapement levels for spring/summer chinook salmon (Table 5.4-3). For this assessment to be correct, the large degree of uncertainties associated with estimating predicted post drawdown values of survivals, removal, transition, and equilibrated periods would need to almost immediately return to 1960 conditions within 2 to 5 years with respect to habitat, predation, and other factors influencing river habitat suitability. It is unlikely that 1960 conditions would occur in this timeframe. Also, this outcome does not consider recent PIT-tag data that show that in-river survivals through the Snake River dams can exceed the 85 percent reach survival criteria which was used for the drawdown simulations. Dam breaching meets these escapement levels in 82 percent of the runs while, for the other alternatives, there is a range of 47 to 50 percent of runs that meet recovery criteria. Dam breaching is, therefore, the more robust or least risk-averse of the alternatives, once all assumptions are acceptable.

Table 5.4-3. Average Fraction of Runs (Across All, Equally Weighted Assumption Sets) Exceeding NMFS Survival and Recovery Escapement Criteria for Spring/Summer Chinook Salmon for Alternatives 1, 2, 3, and 4

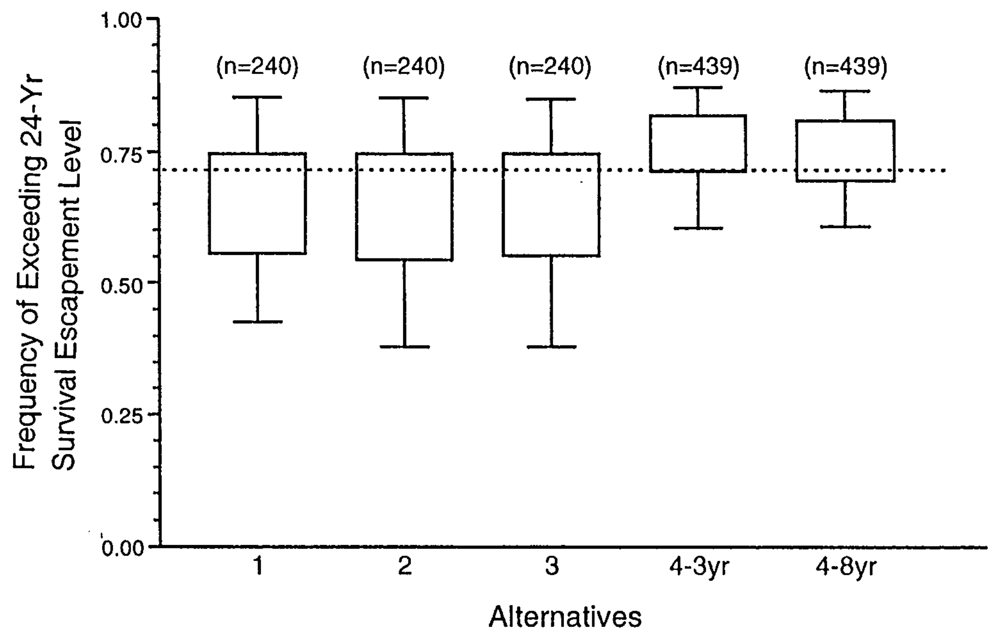
Alternative	24-Year Survival	48-Year Recovery
1	0.65 (240)	0.50 (240)
2	0.64 (240)	0.47 (240)
3	0.65 (240)	0.48 (240)
4 (3-year delay)	0.73 (439)	0.82 (439)
4 (8-year delay)	0.69 (439)	0.82 (439)

Note: Analyses for Alternative 4—Dam Breaching assume 3-year and 8-year delays prior to dam breaching, respectively (Marmorek et al., 1998). The number in parentheses indicates the sample size used to calculate each average.

Differences in the 24-year survival criteria among the alternatives are much less pronounced. The survival goal is met in 69 to 71 percent of the model runs for Alternative 4—Dam Breaching and only slightly less, at 64 to 65 percent for Alternatives 1, 2, and 3. However, single values do not indicate the range of the results for all of the different simulations run. The range of results for meeting the survival and recovery escapements are shown in Figures 5.4-3 and 5.4-4. These figures show the range (top and bottom of each line) and middle 50 percent of all of the outcomes (box). The dashed horizontal lines on these figures represent NMFS criteria for survival and recovery, respectively. These figures indicate that for a specific set of assumptions, all alternatives could or could not achieve these criteria. However, they also indicate that the spread of results is smallest for Alternative 4—Dam Breaching and most of Alternative 4 values exceed the NMFS escapement criteria. NMFS therefore concluded that (Technical Appendix A, Anadromous Fish):

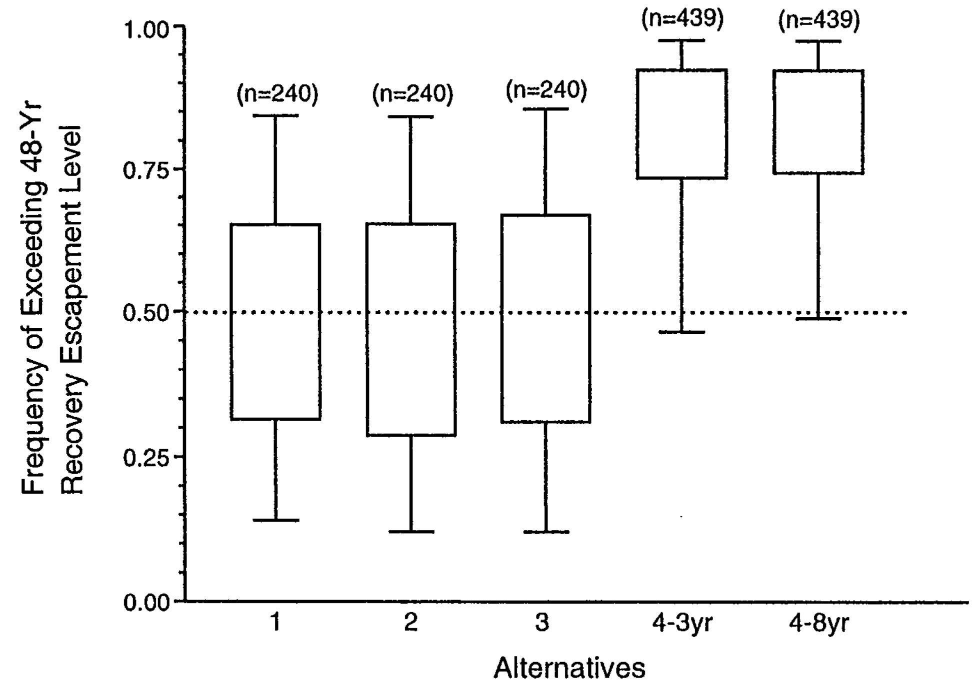
"Thus, breaching (Alternative 4) is more risk-averse in two ways:

- *Breaching consistently yields predicted populations that exceed recovery criteria over a wider range of assumption sets*
- The uncertainty (or variability) in outcomes is consistently reduced with breaching (smaller "middle 50 percent" boxes)."



Note: Alternative 4 (dam breaching) was evaluated assuming both 3-year and 8-year delays. "n" indicates the number of assumption sets for each scenario. Dashed line indicates the 24-year survival criterion. Plots show range (end of lines) and middle 50% of all model runs (boxes).

Figure 5.4-3. Frequency of Exceeding the 24-year Survival Escapement Level for Spring/Summer Chinook Salmon under Alternatives 1,2, 3, and 4, According the PATH Prospective Lifecycle Model



Note: Alternative 4 (drawdown) was evaluated assuming both 3-year and 8-year delays. "n" indicates the number of assumption sets for each scenario. Dashed line indicates the 48-year recovery criterion. Plots show range (end of line) and middle 50 percent of all model runs (boxes).

Figure 5.4-4. Equally Weighted Frequency of Exceeding the 48-year Recovery Escapement Level for Spring/Summer Chinook Salmon under Alternatives 1, 2, 3, and 4 According to the PATH Prospective Lifecycle Model

Critical Assumptions

Analysis of which assumptions most affect model results can be informative in helping to determine how much weight should be placed on the overall outcome of this analysis. PATH found that the choice of CRiSP versus FLUSH and sources assumed for extra mortality had the greatest influence on results (Marmorek et al. 1998). Basically, the average of all CRiSP model results exceeded the 50 percent criteria for the 48-year recovery period, whether Alternative 1—Existing Conditions or Alternative 4—Dam Breaching was analyzed, although Alternative 4—Dam Breaching was still higher, in comparison, average values from the FLUSH model only exceed the 50 percent recovery criteria for Alternative 4—Dam Breaching.

The sources of extra mortality, as assumed by the two models, affect whether this criteria can be met with each of the passage models (Figure 5.4-5).

Another major factor affecting the prediction of future conditions is the assumption about differential delayed mortality or D-values. Because the most recent D-values have been much higher (i.e., lower differential delayed mortality relative to fish remaining in-river) than those that have been used for the PATH model analysis, NMFS ran additional analyses. NMFS compared Alternative 1 to Alternative 4, with varied D-values relative to the 48-year recovery criteria. Using a D-value of 0.8, which is close to the mean value determined for 1994 and 1995, the difference between Alternatives 1 and 4 is 11 percent, much less than the 30 percent difference estimated by the PATH analysis (Figure 5.4-6). Also, if no differential delayed mortality were to occur (D=1.0), the difference between Alternative 4—Dam Breaching and Alternative 1—Existing Conditions would only be 2 percent. Additionally, the source of extra mortality plays an important role if dam breaching is being considered. If D=0.8, dam breaching would increase the chance of achieving recovery criteria by 19 percent, but only if the source of extra mortality is from the hydrosystem (Figure 5.4-7). If the extra mortality has other sources such as degraded stock viability or ocean regime shift, the differences between the alternatives would be even smaller.

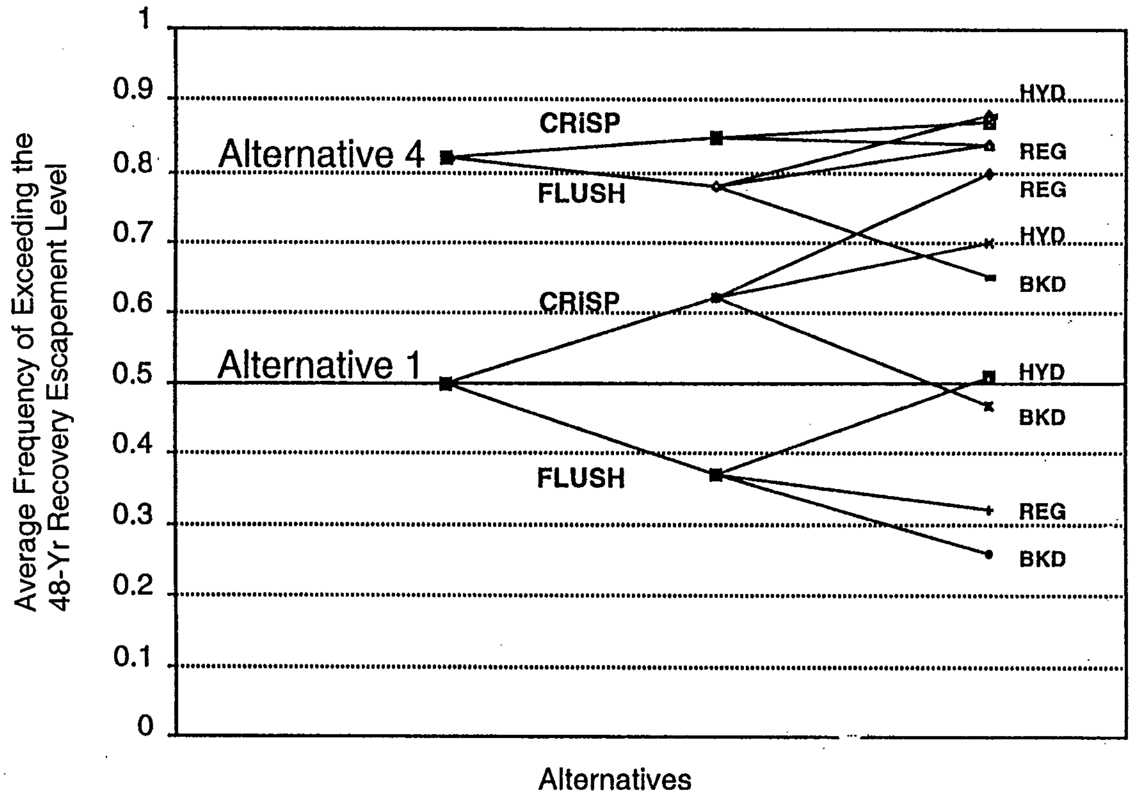
Snake River Fall Chinook Salmon

As noted for spring/summer chinook salmon, many factors affect chances for survival and recovery. These factors are discussed in the NMFS report (Technical Appendix A, Anadromous Fish) and are not be repeated in this section.

The following discussion concentrates on the similar factors noted for spring/summer chinook salmon, where data are available, including a discussion of survival factors, preliminary PATH results, and pertinent habitat information relating to potential restoration of fall chinook salmon under Alternative 4—Dam Breaching.

Survival Factors

Similar to spring/summer chinook salmon, the main parameter addressed by PATH analysis is the smolt-to-adult life stage. However, the level of detail for fall chinook



Note: Solid horizontal line indicates the 48-year recovery criterion. The effects of assumptions shown by alternative (1and 4) are for different passage models (CRiSP and FLUSH) and that of the sources of "extra mortality" which include hydrosystem (HYD), ocean regime shift (REG) and stock viability degradation (BKD).

Figure 5.4-5. Relationship Between Different Combinations of Assumptions and the Average Frequency of Exceeding the 48-year Recovery Escapement Level, As Predicted by the PATH Lifecycle Model.

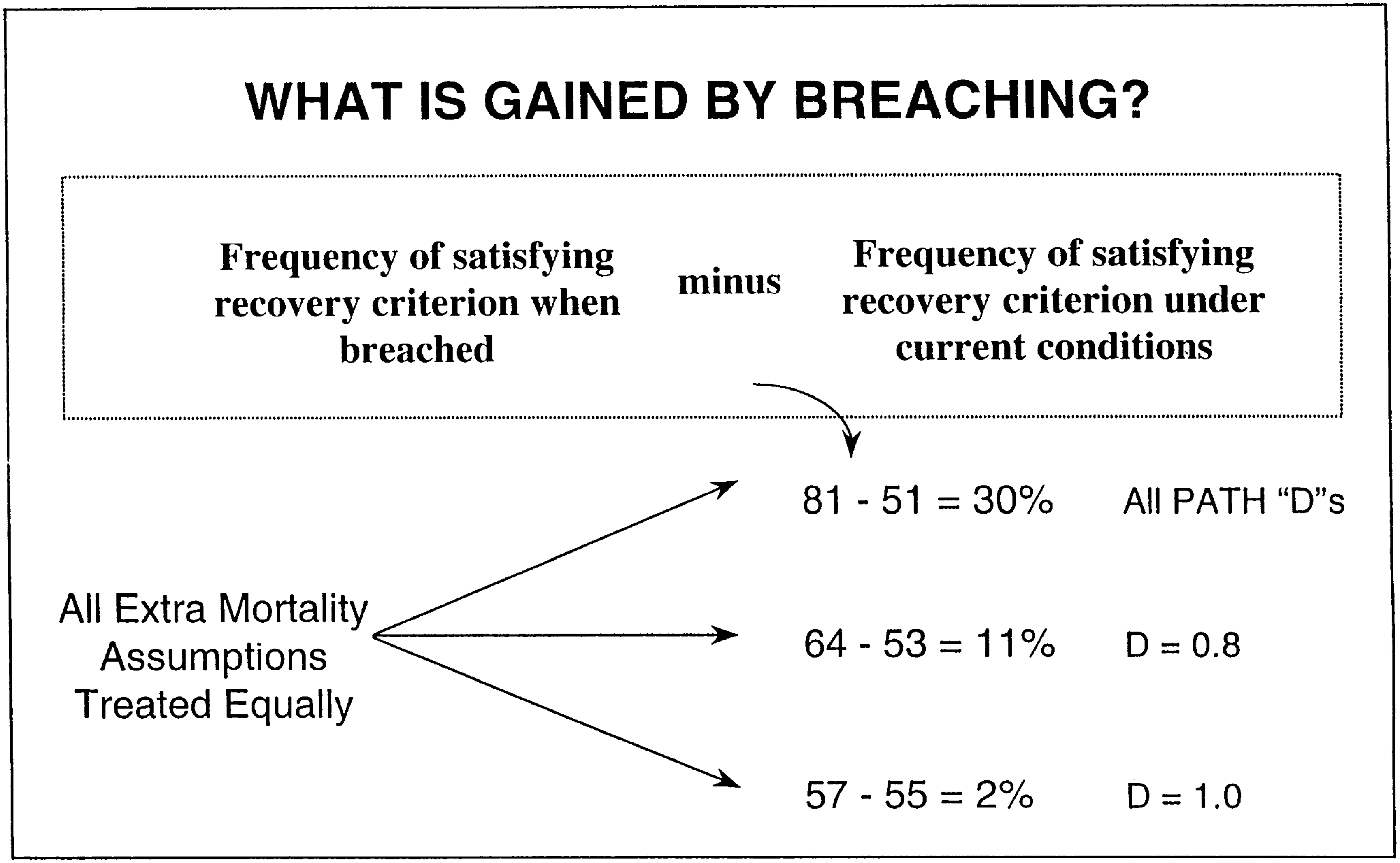


Figure 5.4-6. Demonstration of the Increase in the Equally Weighted Frequency of Exceeding the 48-year Recovery Escapement of Level Spring/Summer Chinook under Dam Breaching (Alternative 4) Compared to the Existing Condition (Alternative 1), Shown for Three Alternative Values of D

If D = 0.8

the increased frequency of meeting the recovery threshold under dam breaching is very sensitive to assumptions about extra mortality

Assumed Source of Extra Mortality	Increased Frequency of Meeting Recovery Goal (under breaching)
Hydrosystem	19%
Degraded Stock Viability	6%
Ocean Regime Shift	2%

Figure 5.4-7. Sensitivity of Breaching Advantage (Alternative 4) to Assumptions about Source of Extra Mortality for Spring/Summer Chinook

salmon modeling was much less because there is much less information available on Snake River fall chinook salmon passage survival. The analysis used by NMFS for fall chinook salmon is primarily based on the Decision Analysis Report for Snake River Fall Chinook Salmon (Draft 5) (Peters et al., 1999). Two passage models were used in this analysis for downstream passage, Fall CRiSP and Fall FLUSH. Both models incorporate features of flow-rate, reservoir elevation, spill rate, and temperature that influence mechanisms such as travel time, FGE, and predation rate. Unlike spring/summer chinook salmon, a very limited amount of information was available to estimate D-values. For this reason, the PATH fall chinook salmon analysis assumed four different sets of D-values to evaluate likely effects of each alternative on meeting NMFS survival and recovery criteria.

Survival to Below Bonneville Dam

Juvenile survival during downstream migration is the major area addressed for each alternative in the model analysis of potential effects on fall chinook salmon. Downstream passage has two areas of concern for survival—dam passage and reservoir passage. How each of these two areas are addressed in the models is summarized below.

Reservoir Survival and Influences of Predation

Several studies have addressed effects of predation of fall chinook salmon during reservoir passage on the Snake and Columbia rivers (Poe et al., 1991; Vigg et al., 1991; Bennett and Naughton, 1999; Muir et al., 1998). For fall chinook salmon, loss from predation during reservoir passage can be substantial. Recent studies by Muir et al. (1998) of PIT-tagged wild and hatchery fall chinook salmon upstream of Lower Granite Reservoir found survival to be low from upriver release points to Lower Granite Dam, but substantially increased later in the season when smolts were larger.

Direct Survival at Dams

Fish that pass dams can use three routes: spillway, turbine, and bypass systems. The mortality rate of fall chinook salmon for each of these routes was estimated or assumed with no variation and these values were used in the PATH models. However, evidence exists that bypass survival can decrease with lower flows and higher temperatures, and also survival can substantially decrease with large increases in spill volume (percent) (TDG studies of Dawley et al., 1997; 1998; 1999). The survival value used for passage through turbines was 90 percent, the same as for spring/summer chinook salmon. Spillway survival was also the same as for spring/summer chinook salmon at 98 percent. Data from 1997 for Lower Granite Dam only, were used in the models to estimate bypass system survival for fish not transported (i.e., captured by the collection facilities but released just downstream of the respective dam and not transported), which was 88 percent. This value includes additional mortality in the tailwater from predation, not just passage mortality.

Fish transported were assumed to have the same direct survival (98 percent) as that for spring/summer chinook salmon because no specific studies have been made for fall chinook salmon. The information on FGE, which is dependent on such project-/dam-specific factors as spill quantity and type of diversion screen used, was used to apportion

fish through each of these passage routes in the model analysis. Sensitivity analysis was conducted assuming two sets of FGE based on assumptions about type of screens to be used (i.e., extended length or standard). It should be noted that because some fall chinook salmon migrate late in the season, some could not be diverted through the bypass system because they arrive after screening systems were closed in October/November.

Components of Post-Bonneville Dam Mortality

As with spring/summer chinook salmon, survival of fish after passing Bonneville Dam (either through transportation or migrating in-river) has a significant effect on overall fish survival and model results. The main factors considered can be grouped into two categories. The first category is the extra mortality that may occur to transported fish (usually represented by a D-value). The second category involves factors affecting all fall chinook salmon survival including climate, ocean, secondary hydrosystem effects, and harvest rate. Factors in the second category are addressed as extra mortality of non-transported fish. The second category includes factors that may be unaffected by the hydrosystem.

Extra Mortality of Transported Fish

Unlike spring/summer chinook salmon, very limited data are available to estimate D-values for fall chinook salmon, the factor used to indicate the relative difference in mortality of transported and untransported fish from the Snake River. A D-value of 1.0 would indicate that transported fish have the same survival from the time they pass Bonneville Dam as fish that migrated in-river to below Bonneville Dam. Since most fall chinook salmon that arrive below Bonneville Dam are currently transported, the D-value estimate has a very large effect on evaluation of the alternatives being considered. The typical method of estimating D-values is to estimate the relative survival to adult return of marked fish released into the river to that of fish that were not transported, typically what is called the Transport:Control ratios (TCR). Because of the lack of available data to estimate D in the normal manner, PATH considered five different sets of indirect methods of estimating D. Although five methods were considered, only the first four were run through the models (see Technical Appendix A, Anadromous Fish). The four methods of estimating D are presented below.

1. Estimate D from TCRs from 1995 PIT-tag data for Snake River fall chinook salmon. SARs are calculated for hatchery smolts PIT-tagged in 1995. The ratio of SAR of transported fish to the SAR of non-transported fish can be used to represent a TCR for that release group.

   TCRs are used to calculate D-values based on the equation:

   $$D = TCR * Vc$$

   where:

   Vc = Survival of in-river migrants from the tailrace of collector dam to below Bonneville Dam

2. Estimate D for Hanford Reach fall chinook salmon based on TCRs from transport studies conducted on Hanford fish at McNary Dam from 1978 to 1983 (Section A.2). TCRs are calculated from mark and recovery of freeze-branded smolts. D-values are then calculated using the equation above. Vcs were estimated either from expansion of reach survival estimates or with a passage model (e.g., CRiSP).
3. Estimate D from Snake River fall chinook salmon spawner-recruit data. D was included as a term in the stock-recruit function and a distribution of D was estimated based on the historical spawner-recruit data. For prospective simulations, a D-value was selected from this distribution and used in each prospective year.
4. Estimate D from Snake River fall chinook salmon spawner-recruit data as above, then adjust it based on comparison of spring/summer chinook salmon D-values estimated from spring/summer spawner-recruit data to estimates from spring/summer transport studies. For spring/summer chinook salmon, TCR-based estimates of D were generally higher than estimates from spawner-recruit data. These differences were used to inflate the fall chinook salmon Ds estimated from the spawner-recruit data.

There are a variety of reasons for believing that each of the above methods may or may not be the best way to estimate D (see Technical Appendix A, Anadromous Fish). However, without further information, there is no scientific basis to discount or accept any one of these over the others. For this reason, the four methods were carried through to calculate the D-values (Table 5.4-4).

Table 5.4-4. T:C and D-Values Resulting From Four Estimation Methods

Method	T:C Ratio Range (mean)	In-river Passage Survival (Vc)	D Range (mean)
1a. 1995 PIT-tag	0.25 to 2.61 (1.18)	0.20	0.05 to 0.52 (0.24)
1b. 1995 PIT-tag	0.74 (1995)	0.20 (1995)	0.15 (1995)
	0.96 (1996)	0.27 (1996)	0.26 (1996)
2. McNary T:C	2.2 to 6.33	0.27 to 0.49	0.6 to 6.0 (1.7)
3. Estimate from Spawner/Recruit data			
CriSP (Upper)	0.10 to 1.35 (0.15)	0.20	0.02 to 0.27 (0.03)
CriSP (Lower)	0.10 to 1.35 (0.15)	0.20	0.02 to 0.27 (0.03)
FLUSH (Upper)	0.10 to 1.20 (0.15)	0.20	0.02 to 0.24 (0.03)
FLUSH (Lower)	0.10 to 1.05 (0.25)	0.20	0.02 to 0.21 (0.03)
4. Adjusted Estimate from Spawner/Recruit Data		0.20	0.16
CriSP (Upper)	0.80	0.20	0.16
CriSP (Lower)	0.80	0.20	0.12
FLUSH (Upper)	0.60	0.20	0.12
FLUSH (Lower)	0.60		

The D-values shown in Table 5.4-4 were used in the development of four hypotheses about how transport affects survival both retrospectively (1965-1992) and prospectively (after 1992). The D-values used in the four hypotheses are shown in Table 5.4-5. Note that the four D hypotheses do not directly correlate to the D alternative methods noted above. The details of each alternative D-value hypothesis are provided in Technical Appendix A, Anadromous Fish and are only summarized in this section.

Table 5.4-5. D-value Hypotheses Used to Estimate Effects on Each Alternative

Scenario	Retrospective D	Prospective D	Evidence
D1	Drawn from posterior distribution of D-values (MLE values around 0.05)	0.24	Spawner-recruit data (retrospective), 1995 PIT-tag estimates (prospective)
D2	1.00	1.00	MCN T:C estimates, NMFS analysis of SARs (retrospective and prospective)
D3	Drawn from posterior distribution of D-values (MLE values around 0.05)	Drawn from posterior distribution of D-values (MLE values around 0.05)	Spawner-recruit data (retrospective and prospective)
D4	0.2	0.2	1995 PIT-tag estimates (retrospective and prospective)

Hypothesis D1

This hypothesis generally assumes the indirect methods of calculating retrospective D, which indicated low values, is correct, but that causes of the low D-values will be improved in the future. This hypothesis would indicate that transport of Snake River fall chinook salmon has generally been ineffective and generally detrimental in the past. D-values were typically low, in the range of 0.04 to 0.24, depending on the method of calculation. This contrasts with the McNary transport results. The reasons for the low D-values are unknown but could include: 1) heavy reliance of truck transport, 2) mark-recapture methods, and 3) release protocol of trucked fish. This hypothesis further shows that conditions that caused low retrospective D-values were improved in 1993 and 1994 (possibly by release methods of trucked fish) and will result in a higher D of about 0.24 in the future. The recent D-value from 1995 PIT-tag data suggests this may be true. Recent preliminary estimates by NMFS suggest a higher D of about 0.8 (this value was not used in this hypothesis).

Hypothesis D2

This hypothesis assumes that both retrospective and prospective D-values are high at, 1.0. This is based on transportation studies conducted on Hanford Reach fall chinook salmon at McNary Dam and estimates of SARs for Snake River fall chinook salmon. Under this hypothesis, different extra mortality trends and mechanisms would need to be considered for the retrospective analysis.

Hypothesis D3

Under this hypothesis, the low retrospective analysis estimated D-values (0.05) are considered correct and would continue into the future. The D-values are variable in this alternative and are based on estimates from the lifecycle model. This hypothesis essentially assumes that conditions relative to fish transportation effects will remain as they have been in the past, and that past conditions resulted in high delayed mortality of transported fish.

Hypothesis D4

This hypothesis assumes that D is 0.2, both retrospectively and prospectively. It is based primarily on the recent PIT-tag results from 1995 and 1996. The underlying rationale is that many factors influence the relationship of in-river and transport fish survival and there is no good reason to believe it will improve prospectively from what has recently been estimated. Recent T:C values have been low—0.74 and 0.99 for 1995 and 1996 releases, respectively. Preliminary information from partial returns of 1997 releases also have a low T:C value of 0.65 based on non-detected in-river migrating fall chinook salmon smolts. However, there are factors that influence the estimates of these T:C values and in-river survival which influence overall D-value estimates.

Extra Mortality of Non-transported Fish

Extra mortality is any mortality that occurs outside of the migration corridor that is not accounted for in fish productivity or direct passage mortality. The actual cause of extra mortality could be changes in ocean conditions, additional delayed effects of hydrosystem, or other additional effects such as disease (e.g., BKD) that have changed over time. This extra mortality may or may not exist, depending on model used.

In the models used, (known as fall chinook salmon Bayesian Simulation Model or "fall BSM"), two periods were considered when extra mortality may have begun to occur. The first is after 1970 and corresponds to the completion of Lower Monumental and Little Goose dams. The second is after 1976, which corresponds to the ocean regime shift. In modeling extra mortality, it was assumed to be zero before 1970 or 1976, depending on which assumptions were made about the cause of extra mortality. The models assumed three different hypotheses concerning possible causes of extra mortality—ocean regime shift; hydro related; and "here to stay" hypothesis, which is other miscellaneous causes that have changed the system effects on fish survival (e.g., BKD, hatchery influences).

Ocean/Climatic Regime Shift Hypothesis

In this hypothesis, extra mortality is an interaction with long-term oscillation in climate which shows a climate regime shift approximately every 30 years. The most recent documented change was in about 1977. Years following 1977 had generally reduced quality of oceans off Washington and Oregon for regional salmon stocks. In addition, land climatic conditions (snow pack, temperature) also worsened. The regime shifts showed an inverse pattern in salmon production between the Alaskan stocks and West Coast stocks over the 20th century (Hare et al., 1999). There appears to be data suggesting ocean conditions do affect the Snake River stocks. Their survival appears to

be correlated with that of Deschutes River fall chinook salmon stock. The relative survival of outmigration year stocks follow a similar trend (although not the same survival rate) as this stock. The outmigration timing and ocean distribution also appears to be similar to the Deschutes River fall chinook salmon so that the trends in survival may be related to ocean conditions. In addition to these ocean conditions, the model assumed oscillations every 30 years going from no extra mortality resulting from "good" ocean and climatic conditions for 30 years, to some extra mortality in the next 30 years when conditions are "poor." Because of limited information, it is difficult to determine precisely when or if these conditions will occur in the future. If this hypothesis is valid, dam removal would not affect this form of mortality.

Hydro-related Hypothesis

This hypothesis assumes extra mortality beginning in about 1970 or 1976 is caused by some factor of passage in addition to direct mortality. The sources could be altered saltwater entry timing, increased susceptibility to ocean predation, increased stress, reduced fitness, or increased disease as a result of passing through the hydro system. As is the case with the other hypotheses, there is a lack of data to prove this hypothesis. This factor is assumed to continue into the future unless the Snake River dams are removed.

BKD or "Here to Stay" Hypothesis

This hypothesis assumes some factor other than hydro or climate has changed and will continue into the future with or without the dams in place. The common sources considered for this factor include fish disease (BKD), hatchery influences (e.g., genetics, predation, competition) on fish survival, and reduced stock size which can reduce stock viability.

Harvest Effects

Unlike spring/summer chinook salmon, the harvest rate both in the ocean and the river can be quite high on fall chinook salmon and may have a significant effect on recovery of the stock. In the modeling of this ESU, PATH considered six harvest scenarios. The scenarios included variations in in-river and ocean harvest rates. They ranged from increases of up to 15 percent in ocean and river harvest to decreases up to 75 percent in ocean and 50 percent in-river harvest rate (see Technical Appendix A, Anadromous Fish for details).

Alternatives Analysis

PATH Results for Fall Chinook Salmon

The model analysis of fall chinook salmon has not undergone the same level of effort and regional review as the spring/summer chinook salmon analysis. Many areas are under additional analysis, including interpretation of PIT tag results of rearing fish, mortality from transportation, and effects of climate and harvest assumptions on the performance of alternatives. The alternatives were evaluated considering these limitations.

Despite the above caveats about the incomplete nature of the PATH analyses, examination of the results is still informative. PATH analyses evaluated Alternatives 1, 2, and 3. Alternative 1—Existing Conditions was not evaluated directly because it is essentially the same as Alternative 2—Maximum Transport of Juvenile Salmon. PATH model response variables for these different actions include trends in projected numbers of spawners over time, and average survival and recovery frequencies over short- and long-time scales. Independent of which D-value hypothesis was used, the assumed chance of meeting NMFS "survival" criteria was generally high for all alternatives (Table 5.4-6). Many of the alternatives and alternate D-value hypotheses also met recovery standards. Only Alternatives 2 and 3 with assumed low and unchanging D-values in the future (D3 and D4), did not meet recovery escapement. Dam breaching had noticeably much greater average escapement than other alternatives except where D was assumed to be high. As is apparent from these effects, assumptions about transport survival have a large influence on both estimates of escapement and meeting recovery standards.

Generally low assumed transport survival resulted in low escapements for Alternatives 2 and 3, but high escapements for Alternative 4—Dam Breaching. When transport survival was assumed to be high, escapement estimates were very similar among alternatives.

Much of the difference among escapement estimates with and without drawdown is the result of estimates of substantially more spawning habitat resulting from drawdown being included in the modeling effort (Peters et al., 1999). PATH conducted a sensitivity analysis to determine the effect of inclusion of additional spawning habitat in the model. This analysis determined that median spawner estimates increased 40 to 50 percent compared to estimates assuming no increase in spawning habitat. Based on increased river miles, NMFS noted (Technical Appendix A, Anadromous Fish) that an assumed potential for an additional 5,000 spawners would be developed following dam breaching. The actual increase in spawning habitat that would be used is unknown, but two estimates of possible spawning area increase have been developed. Marmorek et al. (1998) assumed a 77 percent increase in spawning based just on relative increase in river miles when reservoirs are converted to river. From GIS estimates, based on mapping done in 1934, about 24 percent of the length of the current reservoir area that would become river was considered to likely have habitat features (substrate, depth, velocity) that could be considered suitable for spawning habitat. While both methods suggest that substantial spawning area would be formed at some period after drawdown in the future, the actual number of fish that would use this region is only speculative. Considering that most of the historical spawning area of fall chinook salmon was considered to be well upstream of this region (i.e., in the Snake River Hells Canyon) (Waples et al., 1991), the question of magnitude of fall chinook salmon spawning in this area after drawdown is unclear.

PATH has also conducted a series of analyses to examine survival and recovery fractions under a range of future ocean/Columbia River harvest scenarios. PATH developed a set of alternative harvest scenarios in which ocean and in-river harvest rates are reduced incrementally. Generally, results from model runs with decreased ocean harvest, with or without in-river harvest, met or exceeded survival and recovery standards.

Table 5.4-6. Summary of Major Quantitative Results by Alternative

Performance Measure	Alternative	D Hypotheses (retrospective/prospective D-value) D1 (0.05 / 0.24)	D2 (1.0 / 1.0)	D3 (0.05 / 0.05)	D4 (0.20 / 0.20)
Number of runs per action/D hypothesis[1/]	2	2	6	2	6
	3	2	6	2	6
	4	16	48	16	48
Average spawning escapement over 100-year simulation period	2	5,028	5,259	2,131	2,328
	3	5,515	6,273	2,151	2,535
	4	21,312	8,325	20,842	15,425
Frequency of exceeding survival escapement threshold, 24 years	2	0.99	0.94	0.80	0.90
	3	0.99	0.95	0.73	0.89
	4	0.99	0.94	0.89	0.92
Frequency of exceeding survival escapement threshold, 100 years	2	1.0	0.96	0.80	0.92
	3	1.0	0.98	0.72	0.93
	4	1.0	0.97	0.97	0.98
Frequency of exceeding recovery escapement threshold, 24 years	2	0.86	0.70	0.26	0.34
	3	0.90	0.78	0.27	0.38
	4	1.0	0.84	1.0	1.0
Frequency of exceeding recovery escapement threshold, 48 years	2	0.87	0.68	0.28	0.34
	3	0.93	0.77	0.30	0.40
	4	1.0	0.83	1.0	1.0
Fraction of runs exceeding survival and recovery standards	2	2/2	6/6	0/2	1/6
	3	2/2	6/6	0/2	1/6
	4	16/16	41/48	16/16	48/48

1/ More runs are required for drawdown actions because of the uncertain factors that are specific to drawdown (e.g., length of transition period, survival rate in free-flowing river).

Snake River Steelhead

This section discusses survival factors that influence steelhead. It primarily focuses on hydrosystem effects and a discussion of each alternative. Details of the life history stages and effects of harvest and upstream passage are presented in more detail in Technical Appendix A, Anadromous Fish. Unlike previous ESUs, no survival or recovery criteria have been developed for this ESU. Because of the many similarities between steelhead and spring/summer chinook salmon, the performance of each alternative was analyzed relative to predicted changes from conditions for spring/summer chinook salmon.

Survival Factors

As with spring/summer chinook salmon, the smolt-to-adult life stage of steelhead appears to reflect the decline of this stock. However, unlike spring/summer chinook

salmon, PATH analysis has not addressed this stock through the use of passage or lifecycle models. Because of data limitations, it is not possible to perform the same type of model analysis as was done for spring/summer chinook salmon. The lack of known information on historical escapement by stock and comparable escapement estimates for lower river steelhead stocks are two of the reasons that similar analyses are not possible. In addition, because of these limitations, similar NMFS criteria for "survival" and "recovery" are not available. Also, because of these limitations, the analysis of potential effects of each alternative is more qualitative, relying more on comparisons of effects of each alternative relative to the expected changes in spring/summer chinook salmon stocks.

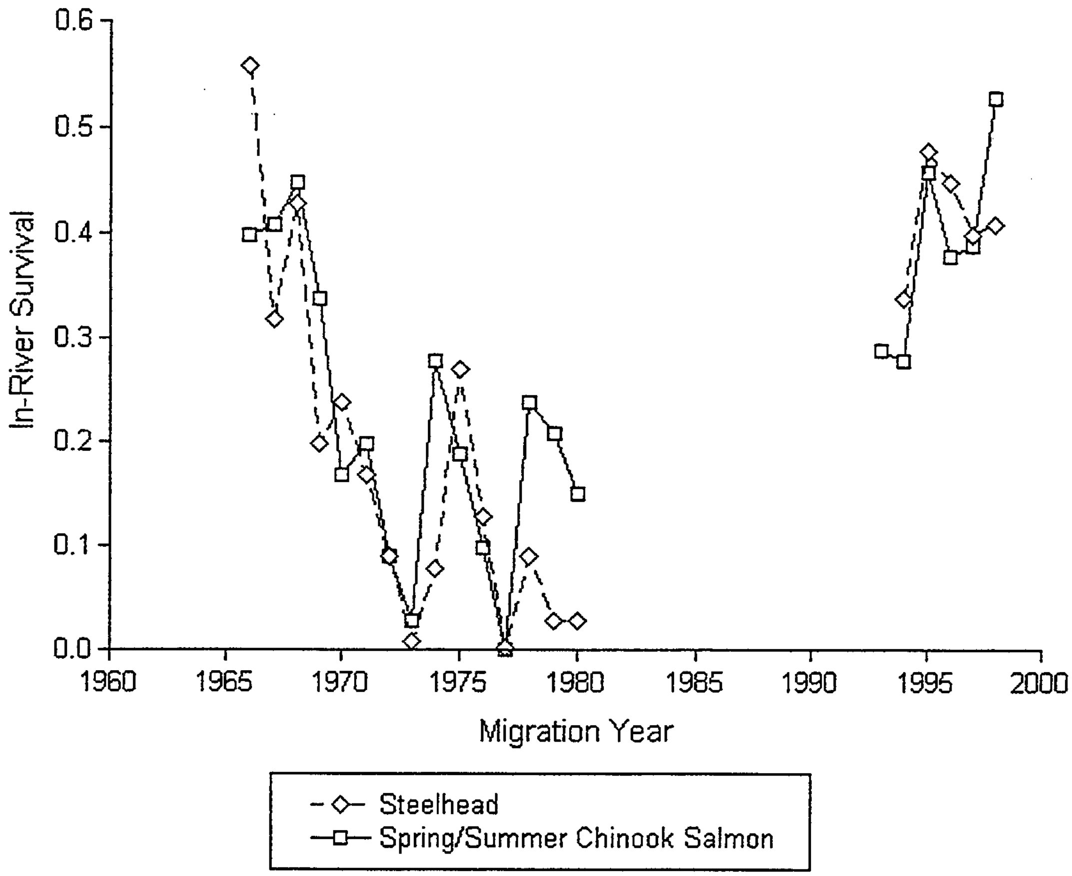
Spring/summer chinook salmon has many similarities that make it a reasonable surrogate to predict relative changes to steelhead for each alternative. However, several differences occur and were considered in the analysis. The analysis separated survival into two categories, direct survival through the hydrosystem to below Bonneville Dam, and survival below Bonneville Dam to return as adults. Since upstream passage survival has been determined by tagging studies, in-river harvest is known, and survival of juveniles during downstream passage is monitored similar to spring/summer chinook salmon. The major unknown survival factor is in the estuary and oceans. Also, uncertainty remains a factor for all of these areas included in the smolt-to-adult life stage.

Direct Survival to Below Bonneville Dam

Unlike PATH, detailed passage models have not been developed for steelhead. However, actual empirical measurement methods of survival during passage have been similar. Until recently, no direct measures of survival from Lower Granite Reservoir to below Bonneville Dam were possible. Estimates have relied on mass marking and recovery at various dams upstream of Bonneville Dam. More recently, the addition of PIT-tag detectors at Bonneville Dam, combined with trawl-mounted detectors, allowed direct in-river survival estimates during 1997 and 1998 (Smith and Williams, 1999). Estimates of total in-river passage survival through the system were developed by expanding reach survival to the whole system (Figure 5.4-8). More recent estimates (1994 to 1997) reflect PIT-tag data for passage through the entire hydrosystem. These data indicate that steelhead that remained in-river have, in recent years, had similar passage survival to those fish in the 1960s when fewer dams were present. Considering that since the 1970s a large portion of steelhead have been transported (with direct transport survival of about 98 percent), total direct passage survival in recent years (1990s) would have been higher than even in the 1960s.

However, SAR values have not followed this same trend. SAR values followed the declining direct in-river survival trend through the late 1970s. However, SAR, increased in the late 1970s and 1980s followed by a decline again during the 1990s. When the region began high voluntary spill under waiver for spring chinook salmon passage, it also affected steelhead.

It is well documented that steelhead are more vulnerable to TDG >110 percent, and in the 1990s, after an entire lifecycle, over 4 to 5 years of spill resulted in Columbia and Snake River steelhead listings.



Note: Some modifications of measured values are made for comparison purposes.

Figure 5.4-8. NMFS (in-River) Reach Survival Estimates, Expanded to Represent Survival Through All Lower Snake River and Lower Columbia River Projects in Existence During a Particular Period Using the Method in Smith and Williams (1999)

Survival Below Bonneville Dam

Because the most recent (early 1990s) decline in steelhead SARs do not follow direct system passage survival trends, other possible sources of this decline were considered by PATH. Like spring/summer chinook salmon, several possible sources of this additional mortality are considered, including: ocean/climate effects, indirect hydrosystem effects, and reduced stock viability.

Ocean and Climate Effects

Several studies have found correlations between the survival of Northwest steelhead stocks and ocean conditions (Coronado-Hernandez, 1995; Cooper and Johnson, 1992; Welch et al., In Press). Most authors have indicated that ocean conditions and reduced survival, beginning about 1989 and continuing into the 1990s, were correlated. The survival patterns observed for some summer steelhead stocks in the Northwest (Coroando-Hernandez, 1995) mimic those of wild Snake River steelhead SARs. Factors such as increases in ocean temperatures after 1977 and anomalous ocean conditions throughout much of the Northeast Pacific after 1990 could be the cause (Watanabe and Nitta, 1999).

Indirect Hydrosystem Passage Effects

Two possible sources of delayed hydrosystem mortality for steelhead were considered by PATH (as they were for spring/summer chinook salmon). These sources were differential delayed transport mortality and delayed bypass system mortality. Data are limited for estimates of delayed transport mortality, with estimates of the D-value for steelhead limited to one year (1995). The D-value for that year was 0.32. This value is much lower than recent spring/summer chinook salmon estimates of about 0.87. Recent work suggests that some additional possible delayed mortality could be attributed to passage through the hydrosystem (Muir et al., 1998). However, the level of effect appears to be dependent on the specific passage route (e.g., spillway, bypass system, or turbine) a steelhead takes while migrating through the system. One explanation for these differences could be the accumulated physiological response to system-wide spill, increasing spill mortality at each dam from gas bubble disease caused by an elevated magnitude and prolonged exposure to TDGs greater than 120 percent, even through the estuary. This is a common effect that increases susceptibility to predation for both in-river and transported fish.

Extra Mortality and Reduced Stock Viability

Several sources of extra mortality could be possible for steelhead. Those considered as likely sources include reduced stock viability and delayed hydrosystem effects. The mechanisms for this mortality are the same as those discussed for spring/summer chinook salmon (see earlier section) and are not repeated here in detail. Instead, they are only generally discussed with any differences noted. Reduced stock viability was thought to result from increased BKD infection and severity, which would affect fish after they leave the hydrosystem. Other sources of extra mortality could include increased predation (e.g., from birds or mammals) and genetic degradation. Genetic degradation could come from interbreeding of hatchery steelhead, which could match the

delayed pattern of reduced survival in the 1990s. Also, the interaction (e.g., competition) of wild fish with hatchery fish could reduce viability. The main source of delayed hydrosystem effects is thought to be stress, particularly from transport. However, this is less likely for steelhead because, while stress has been demonstrated for spring/ summer chinook salmon from being around large juvenile steelhead, the opposite has not been shown for steelhead. Also, the declining SAR trend, beginning in about 1990, does not follow the increase in numbers of hatchery steelhead released (early 1980s) into the basin. As a result, it is less likely that stress is a major factor of extra mortality for steelhead. If spring/summer chinook salmon escapement criteria are again achieved, it is assumed that steelhead escapement criteria (and SARs) would respond accordingly.

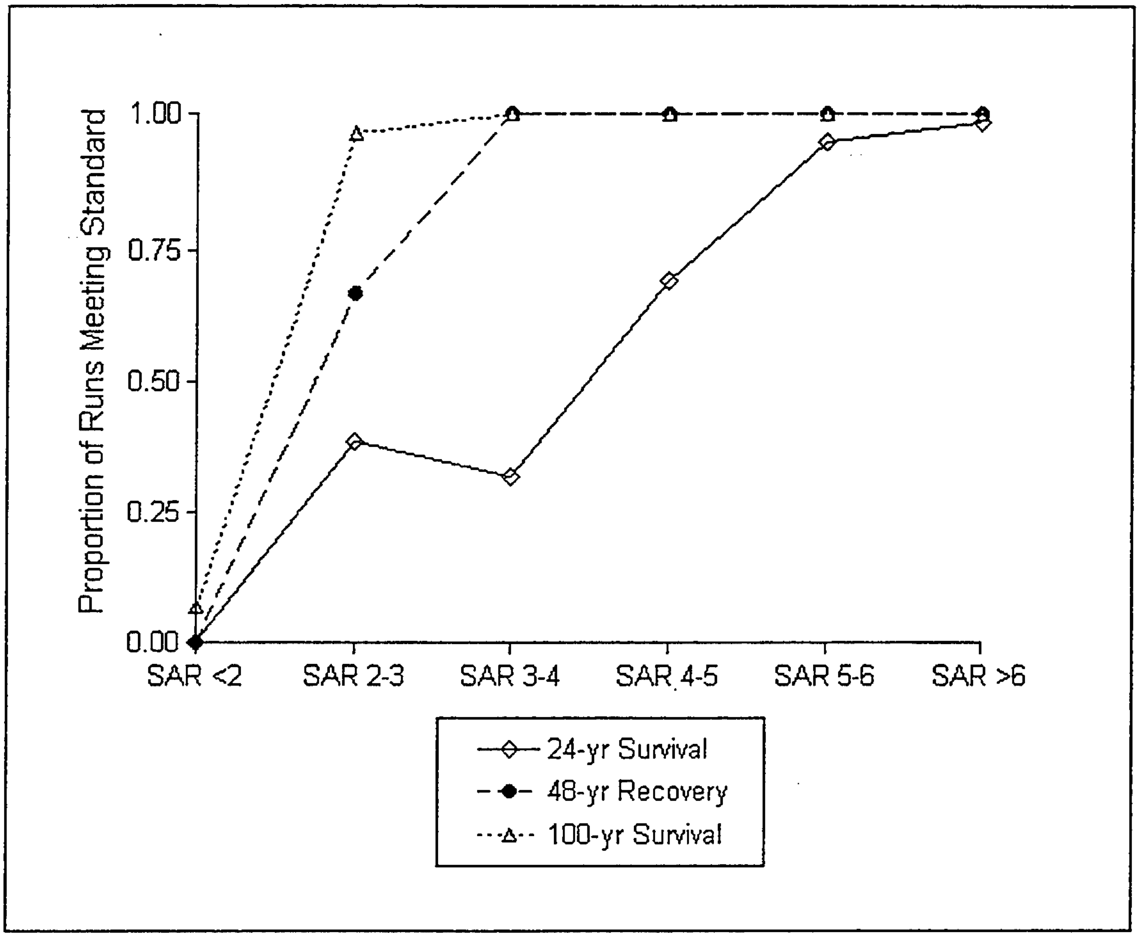
Alternatives Analysis

As noted earlier, the analyses used by PATH for steelhead were not performed in the same manner as those for spring/summer chinook salmon. Instead, conclusions about the effects of each alternative were made by inferences from the spring/summer chinook salmon analysis. NMFS, based on the work done by PATH (Marmorek et al., 1998a), made conclusions using a variety of comparisons and assumptions about spring/summer chinook salmon and steelhead. Basically, NMFS used SAR values for spring/summer chinook salmon and steelhead as indicators of the probability of achieving the 1995 Biological Opinion criteria for survival and recovery, as they relate to steelhead. The details of these components are provided in the Technical Appendix A, Anadromous Fish and are summarized in the following paragraphs.

Analysis of the historical SARs for spring/summer chinook salmon was used to develop survival and recovery levels of escapement for steelhead. It was assumed that historical steelhead SARs would correspond to the same spring/summer chinook salmon escapement criteria. The relative change from historical to current SARs was determined for spring/summer chinook salmon and steelhead. It was assumed that steelhead SARs that occurred historically when spring/summer chinook salmon stocks were at the criteria escapement would also be at the same escapement criteria when these SARs are again achieved. Knowledge of the likely relative effects of future actions, both within and outside of the hydrosystem, was used to help determine how closely different alternatives would change the SARs of both spring/summer chinook salmon and steelhead. The relative changes expected to occur, based primarily on detailed analysis of spring/summer chinook salmon, and any changes needed to meet the criteria, were used to help evaluate the likely effects of the alternatives.

Based on the PATH analysis, several conclusions can be drawn about both the use of spring/summer chinook salmon as a proxy for steelhead and how the analysis influences the estimates of effect of alternatives on steelhead stocks. First, it is apparent that estimated historical SAR values are in the range of those considered suitable for 100-year survival and 48-year recovery criteria, but possibly lower than those for 24-year survival criteria for spring/summer chinook salmon (Figure 5.4-9). This would suggest that historical steelhead SARs should be close to those needed to meet some of the NMFS survival and recovery criteria. The incremental change in SARs needed for steelhead to meet historical levels (assuming a similar relationship to NMFS spring/summer chinook salmon criteria) would be an increase in the current value by

Figure 5.4-9. Probability that Model Runs Resulting in 100-year Median Escapement SAR (Generated by PATH Lifecycle Model as SAR to the Upper Dam) Meet Survival and Recovery Criteria for Snake River Spring/Summer Chinook Salmon



Notes: For example, for model runs resulting in a simulated median escapement SAR between 3.0 and 3.99, slightly more than 30% of these runs meet the 24-year survival criterion, slightly less than 70% meet the 48-year recovery criterion, and all of them meet the 100-year survival criterion. Certainty of meeting the 100-year survival criterion requires a median escapement SAR of at least 3%, certainty of meeting the 48-year recovery criterion requires a median escapement SAR of at least 4%, and certainty of meeting the 24-year survival criterion requires a median escapement SAR greater than 6%.

about 4 times instead of the 11 times increase needed for spring/summer chinook salmon (Table 5.4-7).

Table 5.4-7. SAR Estimates to Upper Dam (Escapement SAR) During Historical and Recent Periods for Snake River Spring/Summer Chinook Salmon and Snake River Steelhead

	Snake River Spring/Summer Chinook Salmon	Snake River Steelhead
Historical SAR Range (Geometric Mean)	0.037 – 0.073 (0.049)	0.045 – 0.064 (0.056)
Recent SAR Range (Geometric Mean)	0.002 - 0.011 (0.004)	0.012 – 0.015 (0.013)
Necessary Incremental Change (Historical Mean ÷ Recent Mean)	11.2x	4.2x

Source: (Petrosky, 1998; Petrosky and Schaller, 1998)

It is expected that the response of steelhead to environmental factors outside of the hydrosystem would be generally similar to spring/summer chinook salmon, but NMFS believes that some differences could occur, as indicated by the difference in SAR trends in the mid to late 1980s. Additionally, PATH did not consider the effect of reduced harvest rate on steelhead, which could contribute substantially to steelhead recovery (see CRI, Subsection 5.4.1.6). Due to the expected similarity of response to hydrosystem conditions, changes in the hydrosystem that achieve the criteria for spring/summer chinook salmon should also do the same for steelhead. Because the incremental change in SARs between current and historical levels is lower for steelhead than it is for spring/summer chinook salmon, meeting the escapement criteria for steelhead would likely take less change in overall hydrosystem survival, if responses to change in the hydrosystem were similar. Reduction in harvest rate would also aid substantially in recovery and would require even less change in hydrosystem survival. This would mean that Alternatives 1, 2, and 3 would more often meet the survival and recovery criteria for steelhead than would be expected for spring/ summer chinook salmon.
Alternative 4—Dam Breaching would likely have the greatest chance of achieving a comparable steelhead escapement criteria to that of NMFS spring/summer chinook salmon.

Snake River Sockeye Salmon

Specific modeling is not possible for Snake River sockeye salmon because little or no data have been collected for the key components that would be used in the models. Additionally, unlike steelhead, no suitable proxy model from one of the other stocks (i.e., spring/summer chinook salmon, fall chinook salmon) is considered suitable for Snake River sockeye salmon because of known differences or lack of knowledge about similarities to other stocks. While NMFS has suggested the probability of recovery in the proposed recovery plan, there is no way to assess whether these probabilities can be achieved for any of the alternatives.

Survival Factors

While no modeling information is available, it is apparent that many portions of the lifecycle of Snake River sockeye salmon, including passage through the hydrosystem, are affected in a manner similar to other stocks that do have available information. The smolt-to-adult survival rate has decreased by 90 percent from the period 1955 to1964 to a range of about 0.8 percent to 0.07 percent from 1991 to 1996. This indicates that survival of this stock is similar to other stocks over similar time periods. The following sections discuss what is known about survival of Snake River sockeye salmon both within and outside of the hydrosystem, concentrating on those factors that could be critical for future recovery as it relates to each alternative.

Survival to Below Bonneville Dam

No studies are available on survival of Snake River sockeye salmon smolts as they pass through the hydrosystem, either by transportation or in-river migration. However, there are indications that some hydrosystem effects could be more severe for sockeye salmon than for some of the other stocks. For example, sockeye salmon, on a system-wide basis, are more vulnerable to TDGs and GBT resulting from spill. Also, the descaling rate remains high for sockeye salmon relative to other species, especially for wild sockeye salmon. However, no documentation of increased mortality of sockeye salmon from scale loss is available. Additionally, FGE from turbine screens is lower for sockeye salmon than it is for yearling chinook salmon and steelhead, as determined at McNary and John Day Dams, except when they pass through the most up-to-date ESBSs. Sockeye salmon migrate deeper in the water column, which could account for this difference. This lower FGE could contribute to higher mortality, particularly if fish pass through turbines. Changes in flow rate or velocity have been reduced by reservoirs in the Snake River System. There is an indication that the migration rate of upper Columbia River sockeye salmon does correlate with flow rate and water temperature when these fish pass through the lower Columbia dams.

Survival Below Bonneville Dam, the Estuary, and Ocean

Concerns about the effects of changing ocean conditions, marine mammal predation, and bird predation in the lower river are all possible factors affecting the survival of downstream migrating sockeye salmon (similar concerns exist for other Snake River stocks). However, no specific data are available concerning their effects specific to Snake River sockeye salmon.

There is no information on ocean distribution of Snake River sockeye salmon, so it is not possible to make inferences about changing ocean conditions on these stocks. Specific impacts from bird predation in the lower river have not been determined because so few tagged sockeye salmon are available, but bird predation is very likely an important factor. While adult sockeye salmon have been observed with increasing occurrences of marine mammal wounds when they pass upstream at the dams, overall effects to populations can not be determined (Fryer, 1998).

Hatchery Release Effects

The effects of releasing hatchery fish could be similar to the effects on other Snake River stocks downstream of Bonneville Dam. Again, no specific data are available for this stock. These effects could include stress from encounter with larger fish (e.g., steelhead), increased opportunity for disease transmission, and predation. However, the effect of extended hatchery releases that could result in genetic impacts from cross-breeding with wild stocks is less likely to be a factor for sockeye salmon. The only hatchery operations for sockeye salmon on the Snake River System are those that began in 1991 as part of a captive brood stock program that was initiated to avoid extinction of the stock. Therefore, genetic effects are unlikely at present. However, should the captive broodstock program continue for an extended period, negative genetic effects could result.

Alternatives Analysis

Because of the lack of species-specific information or a suitable proxy stock, good estimation of hydrosystem effects on Snake River sockeye salmon is not possible. Sockeye salmon have a deeper migration route which will reduce their ability to be diverted by screens and transported, and may result in this species being more susceptible to turbine mortality, even with ESBSs. However, spill and screens should help reduce their mortality. It is therefore reasonable to assume that actions designed to benefit the recovery of other Snake River stocks should benefit sockeye salmon.

Summary of PATH Model Analysis

PATH model analysis was only available directly or indirectly for three of the four listed anadromous salmonids ESUs in the Snake River. Based primarily on the model results of PATH for the other species, consistently higher relative probabilities of exceeding survival and recovery escapement criteria occurred for Alternative 4—Dam Breaching than for Alternatives 1, 2, or 3. Differences in relative probability were most pronounced for the 48-year recovery criteria. However, predictions of the relative differences between Alternative 4—Dam Breaching and any of the other alternatives would be highly dependent on assumed values used for future conditions of one parameter, delayed transport mortality. If this value is low, differences among these two groups are estimated to be relatively large. However, if they are high, differences could be slight.

Spring/Summer Chinook Salmon

PATH model results indicate Alternative 4—Dam Breaching, would meet NMFS survival and recovery criteria more frequently than the other dam retention alternatives evaluated (Alternatives 1, 2, and 3). The difference between Alternative 4—Dam Breaching and other alternatives is a relative probability increase of about 30 percent in satisfying recovery criteria (Figure 5.4-6). However, recent lower delayed transport mortality information prompted NMFS to analyze runs with higher D-values.

Analysis using D-values approximating those of most recent PIT tag results (from 1994 and 1995) for spring chinook salmon resulted in differences between all alternatives,

with the relative probability of achieving recovery criteria narrowing to about 11 percent. When no delayed transport mortality was assumed, the difference in achieving recovery criteria was only 2 percent among the alternatives. This indicates that if adverse delayed transport effects in the future are closer to or better than most recent information, then there is little overall statistical advantage to dam breaching relative to NMFS recovery criteria. NMFS has suggested that obtaining suitable information to determine a more accurate D-value could take 5 to 10 years. However, delay in making a decision about breaching carries the increased risk of extinction of some spring/summer chinook salmon stocks because of their current low abundance. PATH analysis indicates approximately an 8 percent increased reduction in mean probability of meeting survival threshold population over the next 24 years, if breaching is not pursued.

Fall Chinook Salmon

PATH analyses indicated that Alternative 4—Dam Breaching, across all assumptions, was more likely to meet the NMFS recovery and survival criteria than other alternatives. Alternative 3—Major System Improvements had a slightly higher frequency of meeting the survival and recovery criteria than Alternatives 1 and 2 (Alternatives 1 and 2 were considered by PATH to be the same). However, relative differences among alternatives, was highly dependent on assumptions about differential delayed transport mortality (Table 5.4-6). PATH used four sets of hypotheses about delayed transport mortality (as represented by D-values in the analyses). The NMFS survival criteria were met with all four sets of assumptions for all alternatives, with higher values for dam breaching. Recovery criteria were met for two of the four sets of D values for all alternatives. Only when D was assumed to be low (0.05 or 0.20) was recovery not met by the non-dam breaching alternatives. When D was assumed to be high (1.0), or increasing in the future, there was little difference between dam breaching and the other alternatives in meeting survival and recovery criteria.

Estimates of future spawner escapement were always higher for dam breaching, and in all but one of the four D sets, much higher. Differences among alternatives in escapement were slight when D was assumed to be high (1.0). Dam breaching also would have the added benefit of increasing the spawning area of fall chinook salmon with the change from reservoir to river conditions. The exact area is not known, but one estimate, based just on increased stream miles, is a 77 percent increase in spawning habitat over current conditions. Another estimate based on projected habitat characteristics (depth, velocity, and substrate) indicated that 24 percent of the new river habitat would be suitable for spawning. Part of the increase in spawners projected for dam breaching in the models is based on this assumed increase in spawning habitat. However, existing spawning habitat (without dam breaching) has a projected carrying capacity of 7,100 spawners, more than enough to meet the needs of the NMFS' recommended survival and recovery escapement levels. Additionally dam breaching (Alternative 4) may reduce the high predation rate of fall chinook salmon juveniles in what is currently Lower Granite Reservoir area.

Steelhead

PATH analysis did not include the detailed lifecycle modeling and assessment of risk that was performed for spring/summer chinook salmon partly because similar data were

not available. Instead, PATH analysis used the relationship of SAR between spring/summer chinook salmon and steelhead to gauge relative performance of the alternatives. Unlike spring/summer chinook salmon, no NMFS performance criteria have been developed for steelhead. Because there are many similarities in survival factors for these two stocks, this type of comparison was considered suitable. Based on the relative changes in SARs required to meet performance criteria for spring/summer chinook salmon (about 11-fold increase) and that needed for steelhead (about a 4-fold increase), changes in survival determined to meet the survival and recovery criteria for spring/summer chinook salmon should meet the criteria for steelhead.

The relative increase in SARs to meet recovery and survival criteria (for spring/summer chinook salmon) appears to be lower for steelhead. Therefore, fewer improvements in overall hydrosystem survival (i.e., less change from survival under current operations) would likely be needed for steelhead to achieve similar survival and recovery levels. This suggests that while Alternative 4—Dam Breaching would still have a higher probability of achieving any recovery and survival goals, the other alternatives would appear to have a greater chance of also achieving these goals for steelhead than they would for spring/summer chinook salmon.

Sockeye Salmon

No quantitative assessment of sockeye salmon can be done because there is a lack of stock-specific data. While NMFS has established recovery standards for adult sockeye salmon escapement, no analytical method is available to determine the effects of each alternative relative to these standards. No other stock on the Columbia River System has fewer returning adults and is so totally dependent on captive broodstock programs for prevention of extinction. Therefore, measuring of likely effects of different alternatives is not possible.

The 1995 Biological Opinion indicated that sockeye salmon would not be jeopardized from hydrosystem operations. This was based on the fact that hydropower operation was not affecting the captive brood stock program. However, the hydrosystem currently affects migrants because the captive broodstock program (See Section 4.5.1, Anadromous Fish) is releasing fish to migrate through the hydrosystem.

Based on lower FGE, higher descaling, and greater vulnerability to TDGs and GBT, and on the associated increased predation compared to spring/summer chinook salmon, it appears that some of the hydrosystem effects could be more detrimental to sockeye salmon than other species. However, too little is known about hydrosystem passage and other lifecycle information to draw firm conclusions about the effects of each alternative. It is likely that actions which benefit other stocks should benefit Snake River sockeye salmon.

5.4.1.6 Cumulative Risk Analysis

NMFS has developed a quantitative analysis known as the Cumulative Risk Initiative (CRI) to complement the PATH analysis. Unlike PATH, CRI does not rely on large, detailed models. CRI is a chain of connected logical steps, each step simpler and easier to understand than the detailed PATH models. The CRI approach cannot replace PATH's detailed examination of modifications of transport or juvenile fish-passage

systems, and is not intended to do so. Rather, the CRI offers a more simplified approach to help provide information to make decisions on management options. The CRI approach was intended to address the following four factors that were not adequately assessed by the PATH analysis:

- PATH does not estimate the risk of extinction of index stocks or the effects that a delay in actions would have on risk of extinction.
- The performance criteria used by PATH (based on the 1995 Biological Opinion) are difficult to interpret.
- PATH analysis was intended to assess different fish passage actions (e.g., Alternatives 1, 2, 3, and 4) involving primarily the hydrosystem. While the PATH analysis addresses harvest, habitat, and hatcheries through sensitivity analyses, it is difficult to compare the effects of each among alternatives.
- Because a large number of hypotheses and assumptions are used in PATH, it is difficult to make simple comparisons among major groups of effects.

The details of the CRI analysis are presented in Technical Appendix A, Anadromous Fish, and are only summarized here. NMFS divided the analysis into several specific steps, including: 1) estimation of extinction risk for specific populations, 2) development of a demographic matrix that includes such factors as juvenile freshwater rearing survival and estuary-early ocean survival, 3) performance of a sensitivity analysis (e.g., effects of changing mortality rates on certain life stages in the demographic matrix such as estuary-early ocean stage), 4) changing values in the demographic matrix to see how they would affect the overall population growth rate relative to what is needed to reduce the risk of extinction, and 5) evaluation and discussion of whether the changes in the matrix values that produced desired results (i.e., reduce the risk of extinction to the desired level) would be biologically feasible. For clarification, the term "demographics" as it was used by NMFS, refers to the abundance and survival rates at certain life stages that affect population growth characteristics of the fish species of interest.

Methods and Performance Measures of CRI Analysis

The CRI analysis has a different approach than PATH for calculation methods and performance measures. The complete details of methods and the differences between the CRI and PATH analysis are presented in Technical Appendix A, Anadromous Fish. Some of the main differences are as follows:

- CRI does not use density-dependant mortality, making the results more conservative than PATH (i.e., having a lower survival rate than PATH at low numbers of spawners).
- CRI performance measures are estimates of the probability of extinction and changes in average annual population growth rate, while PATH performance measures used comparisons to NMFS "survival and recovery standards."
- "Delayed" and "extra mortality" are not specifically included in CRI.

- CRI uses a demographic matrix model (includes survival rates at various life stages) to estimate current and future population growth rate.
- Using the matrix model, CRI evaluates what effects selected survival improvements, at certain life stages (e.g., juvenile freshwater rearing, downstream passage, estuary-early ocean), would have on population growth rate and extinction risk.
- CRI evaluates what changes in management actions (e.g., habitat improvement, harvest rate reduction, fish transport, dam breaching) would have on demographic life stage survivals and ultimately on achieving reduction in extinction risk.
- CRI analysis evaluates what data exist to support possible conclusions that survival improvements could, in reality, be obtained by dam breaching for hydro or management options in other Hs like harvest reduction.

The salmonid population data used in the CRI analysis included estimates of the numbers of adult spring/summer chinook salmon, fall chinook salmon, and steelhead returning to the Snake River. For spring/summer chinook salmon, the data included estimates of spawners and respective recruits of seven index stocks over a brood year period of 1957 to 1990. The data were based on estimates developed from redd counts. For fall chinook salmon, the analysis was based on data for the one wild spawning stock in the Snake River Basin from 1980 to 1996. The steelhead data were lumped as one group because data for stocks from individual streams are not available. The steelhead analyses evaluated data from 1983 through 1997. All data were the same as the data that PATH developed for its analysis and therefore both CRI and PATH have a common database.

Overall, the CRI analysis can be separated into two types. The first type involves estimating extinction probability under current conditions. The second is the development and use of the demographic matrix.

Extinction Risk Model

The primary purpose of the development of an extinction risk model was to determine the probability and time period of listed ESUs becoming extinct, if no changes in current conditions were to occur. In general, this analysis estimates the chances of Snake River ESUs becoming extinct under Alternative 1—Existing Conditions. As with any estimate of potential extinction, the results from the model developed and used by NMFS have a great amount of uncertainty due to the quality of data and other reasons (Ludwig, 1999).

The extinction model used was a simple linear population growth model developed by Dennis et al. (1991). It involves calculating a measure of the per capita rate of recruitment (i.e., the number of fish that return to the river for each parent). This model uses three critical assumptions that would bias the results if violated. NMFS summarized these assumptions as follows:

- The variability from year-to-year in spawner counts is assumed to be due to a fluctuating environment and not due to sampling error

- Although the populations themselves may be increasing or decreasing (i.e., show a trend), there should be no trend in the rates of decline or increase (such that the rate of decline is getting progressively worse or better)
- Over the range of population sizes being examined, the rates of population change are assumed to be independent of the density of fish.

Although salmonid data violate all of these assumptions to some extent, NMFS (see Technical Appendix A, Anadromous Fish) assumed the magnitude of the violation may be so small that it does not substantively influence the aptness of the model.

NMFS (see Technical Appendix A, Anadromous Fish) described how data and methods used for the extinction model analyses were selected to minimize violations of these three assumptions. Among the three assumptions, the independence of density effects is inconsistent with some other analyses on the spring/summer chinook salmon (Schaller et al., 1999). However, over the period of record used by NMFS, the data indicate this assumption appears generally valid because populations are already at very low levels where density factors have little biological effect.

NMFS' extinction analyses followed the Dennis et al. (1991) approach, with two modifications. First, NMFS used the average number of spawners over a 5-year period for baseline, instead of run numbers for each year separately. The 5-year period reduces the influence of very high or very low escapements in any one year. Second, because recruits of any given brood year (spawning year) return over several years, NMFS made adjustments in estimates of the distribution of returning recruit over time. This was done, based on historical records, by forecasting the weighted proportion of recruits among years returning to the spawning ground from a specific brood year.

Part of the NMFS extinction analysis includes the determinations of the population growth rate, λ (termed lambda). Generally, a λ value of greater than 1.0 indicates an increase in the population from one generation to the next, while λ values less than 1.0 indicate a decreasing population over time. Even though an average λ may be greater than 1.0, the population can still have a significant chance of becoming extinct due to factors such as low initial population size and variability of population growth rate from year to year, with some periods having negative population growth (λ less than 1.0).

The estimate of extinction probability was termed by NMFS as "quasi-extinction" risk. To develop this risk estimate, NMFS used the Dennis et al. (1991) approach to calculate the probability that the number of spawners for an index stock will fall to one or no fish in any single year within a particular time frame (10 years and 100 years). Because salmon and steelhead can live in the ocean for several years, it would actually be possible for a stock to return one or no spawners for a few years in a row, but still have potential spawners alive in the ocean that could return in later years, theoretically allowing a population to increase after it has reached "quasi-extinction." While mathematically this approach overestimates the likelihood of absolute extinction (i.e., stock going to zero and remaining there), its calculations do not include the possibility for natural or other catastrophes (e.g., floods) that could cause fish losses. Also, a population may not be viable from a practical standpoint when numbers are somewhat greater than one (e.g., fish numbers may be so low that individuals may not find a mate

in a stream due to timing and spacing differences). Not including these population risk factors reduces the conservative characteristics of the estimated probabilities of extinction.

NMFS (Technical Appendix A, Anadromous Fish) noted that for recovery to be successful, the chance of quasi-extinction (referred to as extinction hereafter) should be small. NMFS used established risk threshold probability levels for two time periods (10 and 100 years). For general evaluation, a probability of 0.01 was used by NMFS to estimate the risk threshold of extinction for fall chinook salmon and steelhead for the two time periods. NMFS considered a desirable threshold level to be less than 1 percent chance of one or no fish returning any one year, over 10- and 100-year periods. For spring/summer chinook salmon, NMFS used a slightly different threshold because of the potential for natural movement of fish between the seven separate spring/summer chinook salmon index stocks. For this ESU, NMFS selected a less conservative value of 0.10, or 10 percent chance of extinction over the 10- and 100-year periods as a desired result for spring/summer chinook salmon. Snake River sockeye salmon, which are currently maintained by a captive brood stock program, have already fallen below the "extinction" level and, therefore, need no estimate of extinction risk by this method.

While NMFS has selected certain probabilities of extinction as risk threshold values, the suitability of any probability value as providing "acceptable risk " would ultimately be a management decision.

Demographic Matrix Model

NMFS (Technical Appendix A, Anadromous Fish) developed a matrix model to use in exploring quantitative lifecycle characteristics, particularly where mortality occurs for listed stocks. In addition to the extinction model, this was deemed by NMFS to be necessary to help explore where opportunities for recovery may occur. Demographic matrices use a mathematical approach to organize considerations for mortality and reproduction into a framework that is convenient for data presentation, analysis, and prediction. For this matrix, NMFS adopted year-class as one way to iterate salmonid populations from one year to the next. Examples of these matrices are presented in Technical Appendix A, Anadromous Fish. Generally the matrices provide a basis for calculating the survival and abundance at different life stages for a given stock of interest. The basic matrices are flexible and can accommodate a variety of conditions like individual dispersal between populations, impacts of the four Hs, environmental variability and uncertainty in parameter estimation, as well as other items, as indicated in Technical Appendix A, Anadromous Fish.

Most importantly, because this matrix framework is supported by rich underlying statistical and mathematical theory (Caswell, 1989), it has become a standard tool for managing threatened and endangered species (Crouse et al., 1987; Crowder et al., 1994; Doak et al., 1994; Horvitz and Schemske, 1995) and NMFS believes because of the pace it needs to make decisions, this matrix will aid its evaluation. Details on the use of the matrix can be found in Technical Appendix A, Anadromous Fish, along with values calculated for each spring/summer chinook salmon stock, and fall chinook salmon and steelhead. As with the extinction model, one of the components calculated in the model

was λ. This value as noted earlier is an indication of annual population growth rate, with λ values greater than 1.0 indicating an increasing population.

Extinction Risk Model Results

The following sections summarize the result of the extinction risk model for each ESA listed salmonid species in the Snake River. Sockeye salmon were not evaluated, as discussed in the previous section.

Spring/Summer Chinook Salmon

The estimated extinction risk for spring/summer chinook salmon stocks for short-term (10 years) and especially long-term (100 years) periods are considerable under current conditions (Alternative 1—Existing Conditions). For example, stocks from both Marsh Creek and Sulphur Creek have at least a 1 in 10 chance of reaching the extinction level of one spawner or less during the next 10 years (Table 5.4-8). Moreover, when the analysis was extended to 100 years, four of the seven stocks show a better than 1 in 2 chance of going extinct (Table 5.4-8). For the short term, five of the seven index stocks have a probability of extinction less than or equal to 0.1, the value noted by NMFS as being the suitable risk threshold for these stocks. None of the stocks over the 100-year period, however, has an extinction probability less than the extinction risk threshold of 0.10. However, the confidence intervals around these estimates are large. Generally, these results suggest that under current conditions (Alternative 1—Existing Conditions), the short-term chance of extinction for most stocks is not high, while over the long term, the chance of extinction is very high. However, NMFS emphasized that there is major uncertainty in these estimates of risk.

Fall Chinook Salmon and Steelhead

Only one index count based on passage counts over Lower Granite Dam, is available for Snake River fall chinook salmon and one for Snake River steelhead. There are no data for redd counts. For fall chinook salmon, nearly all fish are from one population that spawns in the main Snake River upstream of Lower Granite Dam. While steelhead may have separate populations in the tributaries, similar to spring/summer chinook salmon, data are not available to provide accurate estimates of each of these populations and the estimates rely on counts of fish passing primarily over Lower Granite Dam. This essentially combines all steelhead populations. In the short term (10 years), the probability of extinction is very low (< 0.0001) for both fall chinook salmon and steelhead under Alternative 1—Existing Conditions (Table 5.4-9). The probability of extinction for both species over the long term (100 years) is much higher, with both values greater than the risk threshold of 0.01. Risk to steelhead is also much greater in the long term, with the chance of runs declining to one fish in any one year at 93 percent over a 100-year period.

Table 5.4-8. Extinction Risk of Snake River Spring/Summer Chinook Salmon

Stock	Average Population Growth Rate (λ)	Average Population Size (No. of Individuals) over Last 5 Years	Probability of Extinction Within 10 Years	Probability of Extinction within 100 Years
Marsh	1.25 (0.81-1.92)	60	0.15 (0.01-0.73)	0.88 (0.003-1.0)
Johnson	1.08 (0.87-1.34)	98	0.0009 (<0.0001-0.32)	0.41 (0.0007-1.0)
Bear	1.16 (0.85-1.59)	142	0.01 (0.0001-0.50)	0.59 (0.002-1.0)
Poverty	1.10 (0.87-1.37)	248	0.0002 (<0.0001-0.22)	0.33 (0.0005-1.0)
Sulphur	1.48 (0.89-2.44)	68	0.10 (0.008-0.70)	0.56 (0.004-1.0)
Imnaha	0.999 (0.82-1.22)	415.8	<0.0001 (<0.001-0.17)	0.74 (0.0007-1.0)
Minam	1.40 (0.86-2.20)	115	0.04 (0.002-0.70)	0.41 (0.002-1.0)

Note: Confidence intervals for predictions are listed in parentheses. Analyses for Imnaha and Minam used data from 1980-1995. Analysis for all other stocks used data from 1980-1998.

The reason for such a striking difference between short-term and long-term risks is that both of these stocks are currently at relatively high abundance levels (over 500 fish), which makes it unlikely they can decline below one spawner in only 10 years. However, the long-term (100 years) probability of extinction is more dependent on the annual population growth rate (λ) trends than on existing abundance, which has a greater influence on short-term risk of extinction. For example, the high probability of extinction of steelhead over 100 years is due to the steep decline in λ since 1980. These results suggest that under Alternative 1—Existing Conditions, short-term risks of extinction of populations of fall chinook salmon and steelhead are low, while over the long term, unless conditions change from recent history, the chance of extinction is very high for steelhead, and moderately high for fall chinook salmon. As noted above, there is considerable variability in these estimates that can greatly influence the actual future outcome.

Table 5.4-9. Extinction Risk of Snake River Fall Chinook Salmon and Steelhead

Stock	Average Population Growth Rate (λ)	Average Population Size (No. of Individuals) over Last 5 Years	Probability of Extinction within 10 Years	Probability of Extinction within 100 Years
Fall Chinook Salmon	1.13 (0.89-1.44)	639	<0.0001 (<0.0001-0.16)	0.06 (0.0002-1.0)
Steelhead	0.91 (0.80-1.03)	7767	<0.0001	0.93 (0.0004-1.0)

Note: Confidence intervals for predictions are listed in parentheses. Snake River fall chinook salmon analyses used data from 1980-1996 and Snake River steelhead analyses used data from 1983-1997.

Population Growth Rate Effects on Extinction Risk

Population recovery and extinction risk are inversely related. The extinction risk is primarily affected by two factors—existing population size (number of adults) and population growth rate. In general, higher population growth rates are needed for smaller populations to have similar effects at reducing the risk of extinction than for larger populations. This is shown by the differences in the probability of extinction between fall chinook salmon and spring/summer chinook salmon stocks (Tables 5.4-8, 5.4-9). Current extinction model parameter estimates can be used to determine the changes in population growth rate that would be needed to reduce the probability of extinction for ESA-listed salmonids in the Snake River. NMFS used the data from this model to estimate what relative change (percent) in annual population growth rate (λ) would produce varying probabilities of extinction for spring/summer chinook salmon, fall chinook salmon, and steelhead stocks (Tables 5.4-10 and 5.4-11). Among the spring/summer chinook salmon stocks, NMFS concentrated on Marsh Creek data because this stock appears to be at the greatest risk of extinction (Table 5.4-10).

In general, substantial increases in the annual population growth rate (λ) are necessary to lower the 100-year extinction risk for spring/summer chinook salmon below the probability of 0.01 (50 percent increase for Marsh Creek; 25 percent increase averaged across the seven index stocks of spring/summer chinook salmon). For steelhead, a 10 percent increase in annual population growth rate would be required to lower the 100-year extinction probability to below 0.01. In contrast, fall chinook salmon appear to be much less at risk, since only a 4 percent increase in λ is needed to reduce a 100-year extinction probability to below 0.01. For the Snake River spring/summer index stocks, the 0.01 risk threshold may seem unduly cautious because it is unlikely that these stocks are totally independent (i.e., they may be capable of being rescued by strays from other populations). For this reason, NMFS provided a calculation of the percent increase in annual population growth rate that is needed to reduce the probability of extinction to less than 0.10 for each of the seven populations (Table 5.4-10). NMFS used this extinction probability as the risk threshold for evaluating what change in λ would be needed to recover spring/summer chinook salmon. The average of the seven spring/summer chinook salmon stocks indicates an approximately 12 percent increase in λ would be needed to meet this criterion (Table 5.4-10).

Table 5.4-10. Percent Increase in Population Growth Rate (λ) Required to Lower the Probability of Extinction for Each of the Seven Snake River Spring/Summer Chinook Salmon Index Stocks to Either 0.1 or 0.10 in 100 Years

Stock	Percent Increase in λ Needed to Reduce 100-Year Extinction Probability to: 0.1	0.01
Marsh	27.2	49.4
Johnson	5.1	11.0
Imnaha	7.6	12.1
Bear	11.1	21.2
Poverty	4.3	10.3
Sulphur	19.3	44.5
Minam	11.3	28.2
Average	**12.3**	**25.2**

Table 5.4-11. Extinction Probability for Snake River Fall Chinook Salmon and Snake River Steelhead Associated with Particular Increases in Population Growth Rate (λ)

	Probability of Extinction within 100 Years	
Percent Increase In λ	Fall Chinook Salmon	Steelhead
5	0.005	0.33
10	0.0003	0.008
15	1.3×10^{-5}	1.1×10^{-5}
20	7.1×10^{-7}	9.9×10^{-10}

Demographic Matrix Model Results

Since factors that affect λ also affect the recovery of stocks, it is important to understand how changes in survival of specific life stages will affect overall population growth rate. In this way, an evaluation of the important factors that may affect stocks, both within and outside of the hydrosystem, can be assessed. NMFS used the demographic matrix models to determine the sensitivity of population growth rates to hypothetical changes in specific life stage survivals as a way of presenting how various types of actions (e.g., dam breaching, harvest reduction, fish transport, habitat improvement) may influence recovery. The NMFS analysis is summarized in the following sections.

Spring/Summer Chinook Salmon

NMFS developed a sensitivity analysis to determine what effect a reduction of 10 percent in the rate of mortality for specific life stages would have on the overall population growth rate (λ). It is important to note that this 10 percent reduction in mortality rate means "saving 1 in 10 fish" that would have died in any given specific life stage. This is not the same as a 10 percent increase in survival at the same life stage (see Technical Appendix A, Anadromous Fish for details).

The sensitivity analysis included eight specific categories. While most categories involved a 10 percent reduction in mortality for certain life stages, one of the categories was "increasing the proportion of fish transported by 10 percent" (Figure 5.4-10). The analysis indicated that 10 percent reduction in mortality during the first period of life in fresh water (egg to smolt stage) has the greatest influence on λ and results in an average increase in λ of 28.5 percent for the seven spring/summer chinook salmon index stocks. The reduction in the mortality rate for the first year of life in the ocean (including the estuary) also had moderately large effects, averaging 19.8 percent increase in λ for the spring/summer chinook salmon index stocks. Other factors, including harvest, proportion transported, downstream passage survival, and adult upstream passage survival (from Bonneville Dam to the Snake River basin) all had very minor effects with a 10 percent reduction in mortality (for transport, a 10 percent increase in number of fish transported was used instead of a change in mortality rate). These results are partly driven by the fact that the overall relative mortality is high during the first year of life and again in the first year in the ocean.

The significant point from this analysis is that little gain in overall population growth (and ultimately recovery) would be expected by additional modest reductions in direct downstream passage mortality or increasing proportion of fish transported. This does not indicate that current actions affecting fish passage are not important (see the Spring/Summer Chinook Salmon Summary). It also does not indicate that changing factors influencing survival of fish below Bonneville Dam may not result in significant improvements in the population growth rate.

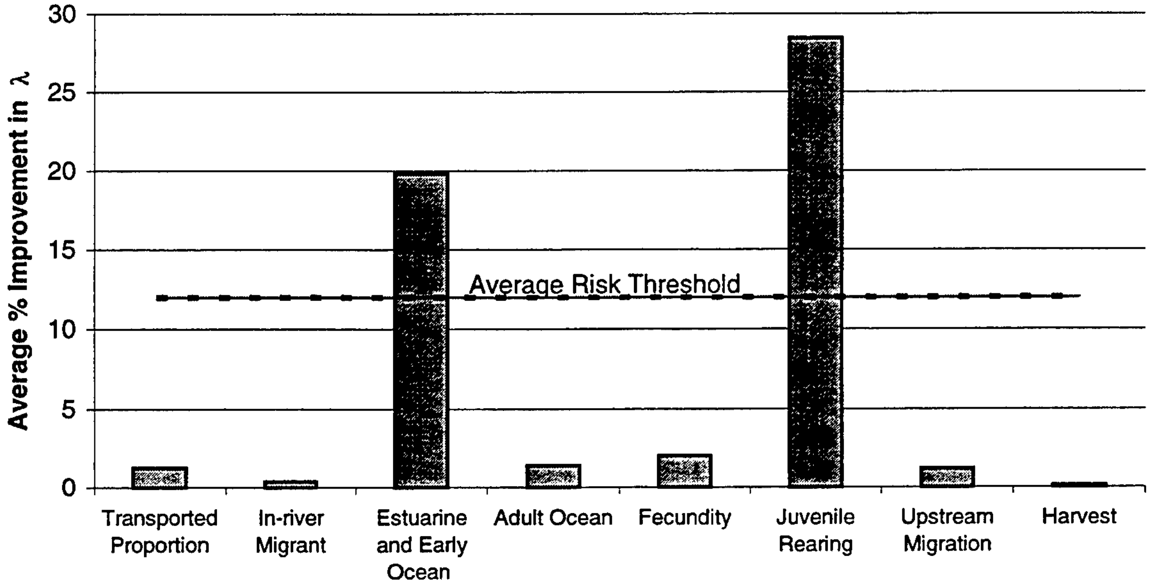


Figure 5.4-10. Increase in Population Growth Rate (λ) Relative to an Extinction Risk Threshold with 10 Percent Reduction in Mortality by Life Stage and 10 Percent Increase in Proportion Transported for Spring/Summer Chinook Salmon

NMFS also evaluated how recent past and some future actions (harvest reductions, dam breaching) may affect the overall population growth rate of spring/summer chinook salmon. This analysis is useful in evaluating whether modifications of the current hydrosystem facilities, like increased transport, are likely to achieve the population growth rate needed to reduce the extinction probability to NMFS' recommended risk threshold levels.

While results in the previous sections suggest that future changes to the hydrosystem can have little effect on overall recovery, the previous CRI analysis did not evaluate the effect of past changes on current population growth rate, and how these changes have ultimately affected survival of the index stocks. NMFS evaluated how the current overall population growth rate (λ) would be altered if survival at various life stages and transportation rates from the 1977 to 1979 period were used in the analysis, plus the effects of harvest rates in the 1960 to 1970 period (Figure 5.4-11). NMFS also evaluated what the effects of changes in future harvest and increases in fish transport would have on population growth rate.

The NMFS analysis provided two important results. First, without the improvements that are currently in place in the hydrosystem—increased fish transport (Alternative 1—Existing Conditions) and reduced harvest rate—spring/summer chinook salmon would likely have been extinct by now due to the predicted very low population growth rate (Figure 5.4-11). The reason for this is that system passage survival was very low from 1977 to 1979 (about 1 percent survival) compared to PATH's estimate of current average survival of 32 percent). Recent data suggest even higher in-river passage survival (about 40 to 60 percent) than that used by PATH for spring/summer chinook salmon (NMFS 1999a). Preliminary 1999 data follow this trend of much higher in-river

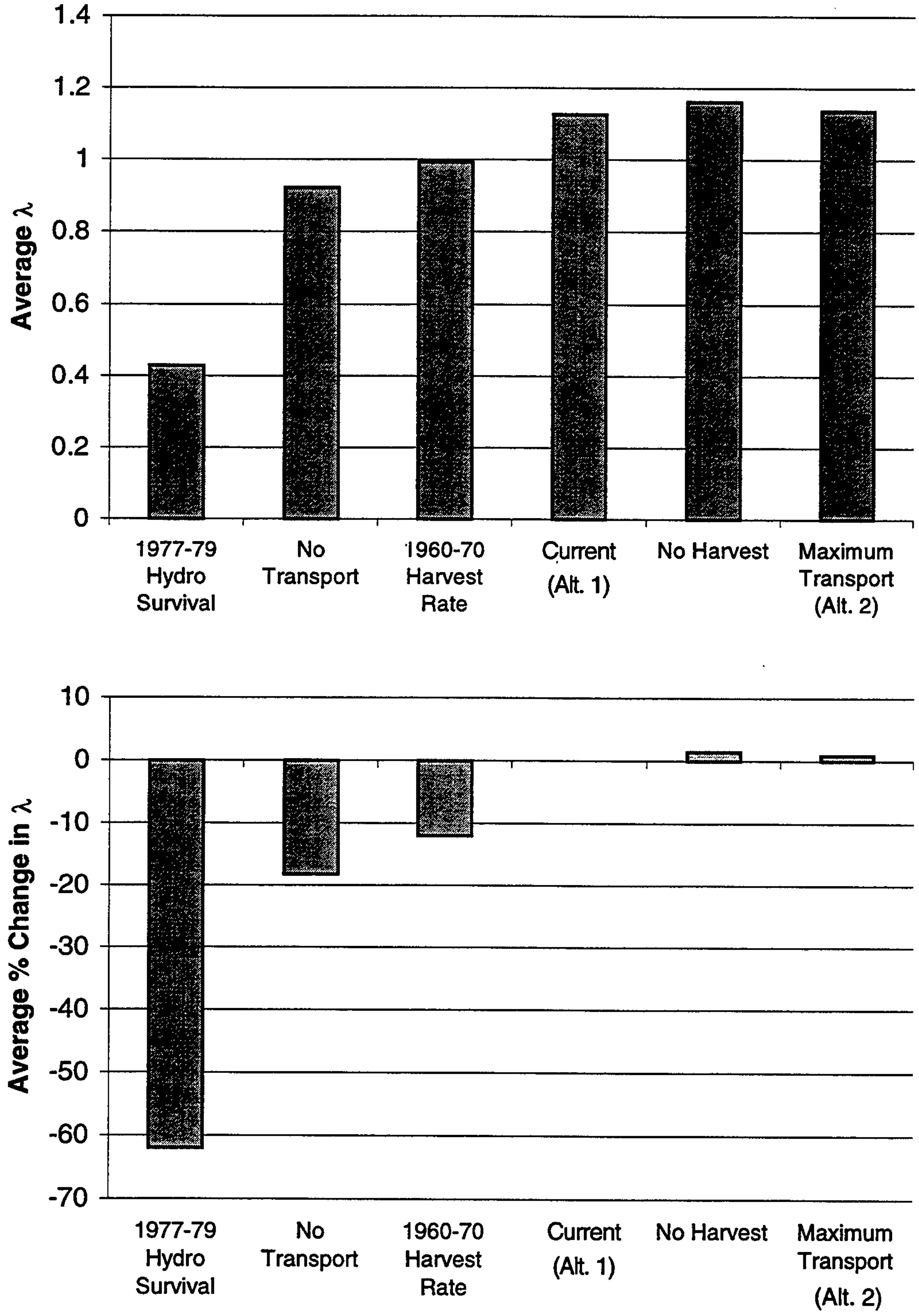


Figure 5.4-11. Average Population Growth Rate (λ) for Spring/ Summer Chinook Salmon and Percent Change from Baseline after Different Hydrosystem Management Scenarios are Simulated

survival ranging from about 45 to 62 percent for spring/summer chinook salmon (Ledgerwood et al., 1999). The annual population growth rate would have been about 62 percent lower than it is currently. Without fish transport, the annual population growth rate would have been about 18 percent lower than under current conditions. The second main point is that even when all harvest is eliminated and transport maximized (Alternative 2—Maximum Transport of Juvenile Salmon), this would have little influence on overall population growth rate (λ would be increased about 1 percent each). Therefore, recovery of Snake River spring/summer chinook salmon would be little affected by these actions (Figure 5.4-11). Not all (100 percent) juveniles can be collected and transported, but even if they could, the annual population growth rate would only increase about 3.4 percent, which is well below the 12 percent value to achieve an average 100-year probability of extinction of 0.1 for the seven spring/summer chinook salmon index stocks. Similarly, if in-river downstream passage survival was increased to 100 percent, population growth rate would still increase by only about 4 percent, again well below the 12 percent value noted above. Overall, this analysis indicates that even if downstream passage survival was 100 percent, it would not result in a population growth rate needed to meet the NMFS extinction risk threshold probability level for spring/summer chinook salmon, mainly because of the high mortality in other life stages.

Another question addressed by NMFS (see Technical Appendix A, Anadromous Fish) was whether enough improvement could be obtained through combinations of various actions, other than dam breaching, to increase population growth rate to a level that would adequately insure that spring/summer chinook salmon stocks would not go extinct. Based on the extinction analysis model, the long-term (100-year) population growth rate would need to increase by an average of about 12 percent to meet the NMFS' recommended extinction probability of 1 in 10 for this ESU. For this evaluation, NMFS assumed a reduction in predation by steelhead on spring chinook salmon (estimated to be about 22 percent), maximum transport (Alternative 2—Maximum Transport of Juvenile Salmon), 10 percent improvement in estuarine/early ocean survival (e.g., water quality improvement, reduced predation, early ocean food conditions), and 10 percent improvement in survival during juvenile rearing upstream of the Snake River dams (Figure 5.4-12). If all of these conditions occurred, a 14 percent increase in annual population growth rate would result. Based on the earlier estimates that a 12 percent increase in average growth rate would be needed to meet the NMFS recommended extinction probability levels, these actions may be adequate to prevent extinction of the spring/summer chinook salmon stocks. This, however, does not say that all or any of these events would occur, but does indicate that improvements in a number of different factors that affect juvenile fish survival could enhance chances of recovery.

Another question addressed by NMFS with this matrix model analysis was whether it was likely that dam breaching alone (Alternative 4—Dam Breaching) could recover spring/summer chinook salmon stocks. To answer this question, NMFS assumed that breaching would have three main effects: 1) altered downstream survival (using the rates assumed by PATH for Alternative 4—Dam Breaching); 2) improved upstream survival of adults, and 3) possibly improved survival below Bonneville Dam assuming "differential delayed transportation mortality" and/or "extra mortality" would no longer be questions. Debate about the importance of the delayed effects of dams on juvenile fish

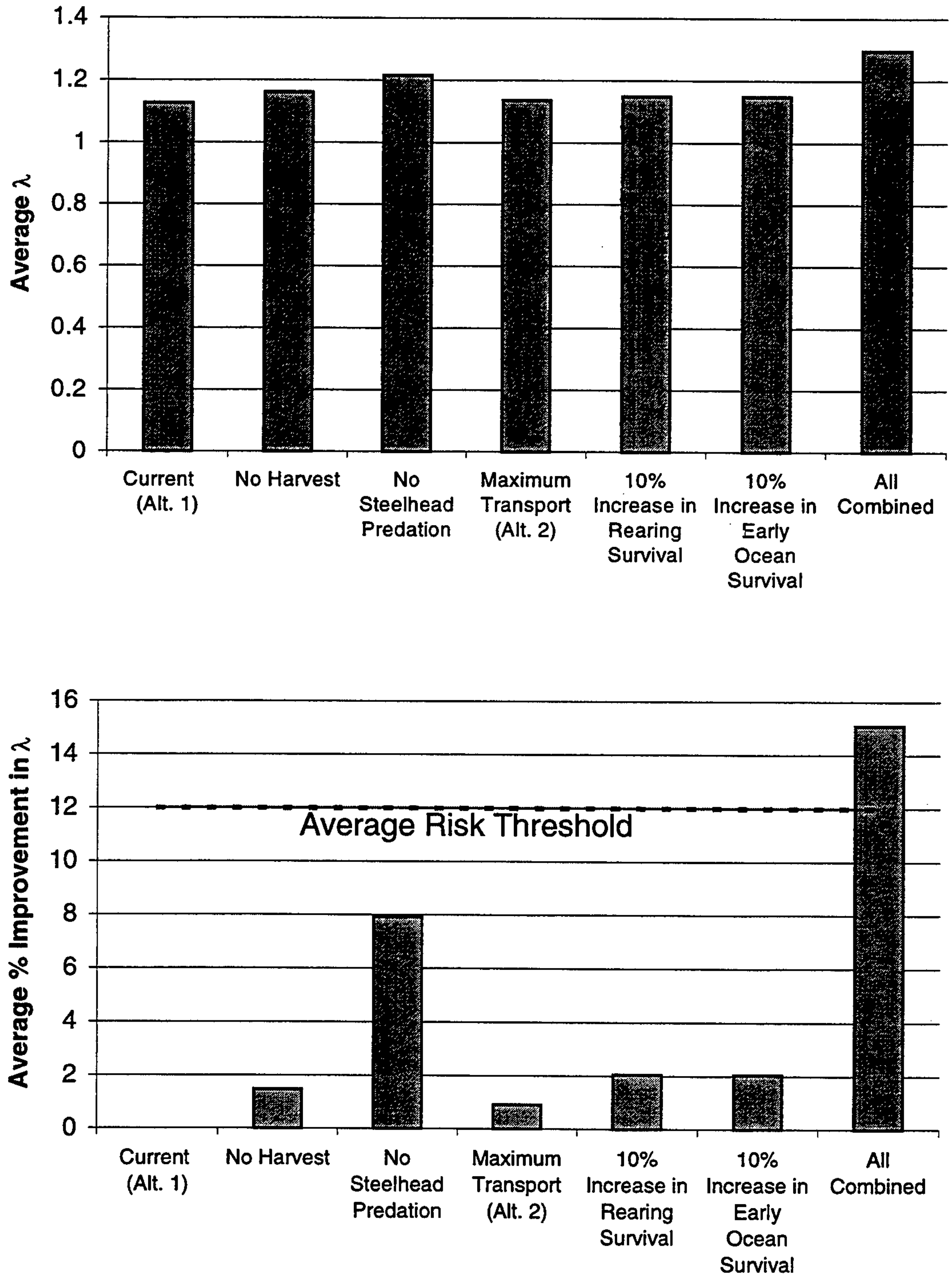


Figure 5.4-12. Average Population Growth Rate (λ) for Spring/Summer Chinook Salmon and Percent Change from Baseline Relative to an Extinction Risk Threshold After Hydrosystem Alterations and Other Management Actions

that have either migrated in-river or were transported downstream of Bonneville Dam has been highly contentious, and data with which to estimate these parameters are generally poor. NMFS, therefore, examined a broad range of potential improvements in survival below Bonneville that could potentially occur after reservoir drawdown.

As noted above, a 12 percent average increase in λ would be needed to meet the NMFS extinction risk threshold probability criteria for Snake River spring/summer chinook salmon stocks. Considering these criteria, NMFS examined the levels of improvement from dam breaching that would be needed in estuarine/early ocean survival in combination with changes in levels of upstream passage survival to achieve this annual population growth level (Figure 5.4-13). Using this criteria, if no increase in passage survival from Bonneville Dam to the Snake River Basin (upstream passage survival) occurs, then a 120 percent increase in estuarine/early ocean survival would be needed to increase population growth rate by 12 percent (Figure 5.4-13). On the other extreme, if upstream passage survival were to increase by 45 percent, estuarine/early ocean survival would need to increase by 60 percent to satisfy the 12 percent increase in λ criteria. The assumption needed for large increases in the estuarine/early ocean survival component would be that differential delayed mortality and extra mortality are contained within this factor and that these would need to change substantially to get the desired increase in population growth rate. For reference, a 20-percent improvement in estuarine/early ocean survival (referred to as "se" in Technical Appendix A, Anadromous Fish) corresponds to a D-value (see Section 5.4.1.5) approximately equal to 0.8, a 60-percent improvement in "se" corresponds to D = 0.5, and a 160-percent improvement corresponds to D=0.2. (Note: The definition of "D" is the ratio of the adult survival of transported fish: adult survival of untransported fish that arrive below Bonneville Dam. If D-values were 1.0, the relative survival of transported fish would be the same as untransported fish below Bonneville Dam; D=0.5 would indicate that once fish are released from the transport barge or truck they only survive at 50 percent of the rate of the fish that have passed through hydrosystem to below Bonneville Dam without transport.)

NMFS further examined the likelihood that dam breaching in combination with other possible actions would achieve the 12 percent increase in λ, to meet the NMFS extinction risk threshold probability (Figure 5.4-14). To do this, NMFS developed what it considered an optimistic scenario for survival improvements from dam breaching, plus other non-dam breaching improvements. For the dam breaching evaluation, NMFS assumed an upstream adult passage survival of 80 percent, downstream juvenile in-river passage survival of 62 percent (which is in the range of current estimates [45 to 62 percent] of 1999 in-river passage survival from Lower Granite Dam to Bonneville Dam; Ledgerwood et al., 1999), and a 30 percent increase in estuarine/early ocean survival (which corresponds to a D of 0.7).

To compare dam breaching effects with non-breaching effects, the non-hydro improvements that were assumed to affect survival were: reducing harvest to zero and improving juvenile freshwater habitat survival by 10 percent. Based on these assumed values, dam breaching and non-hydro system changes (taken separately) would have equivalent effects on population growth rate. Additionally, even in combination, these actions would only achieve an 8 percent increase in population growth rate, which, while

Figure 5.4-13. Possible Alternative 4—Dam Breaching Effects on Spring/Summer Chinook Salmon Population Growth Rate (λ) Relative to Extinction Risk Threshold by Improved Estuarine/Early Ocean and Upstream Passage Survival

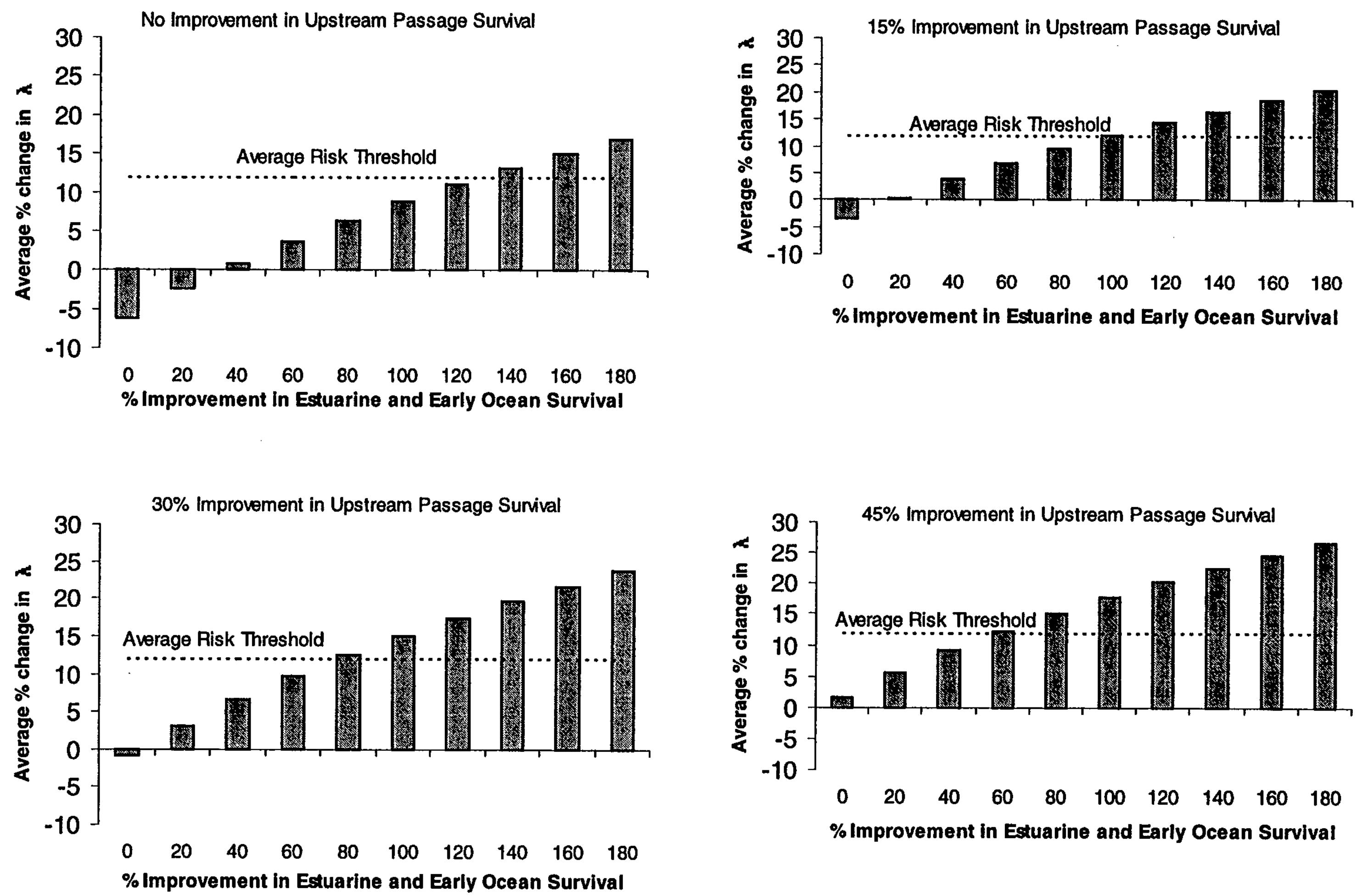
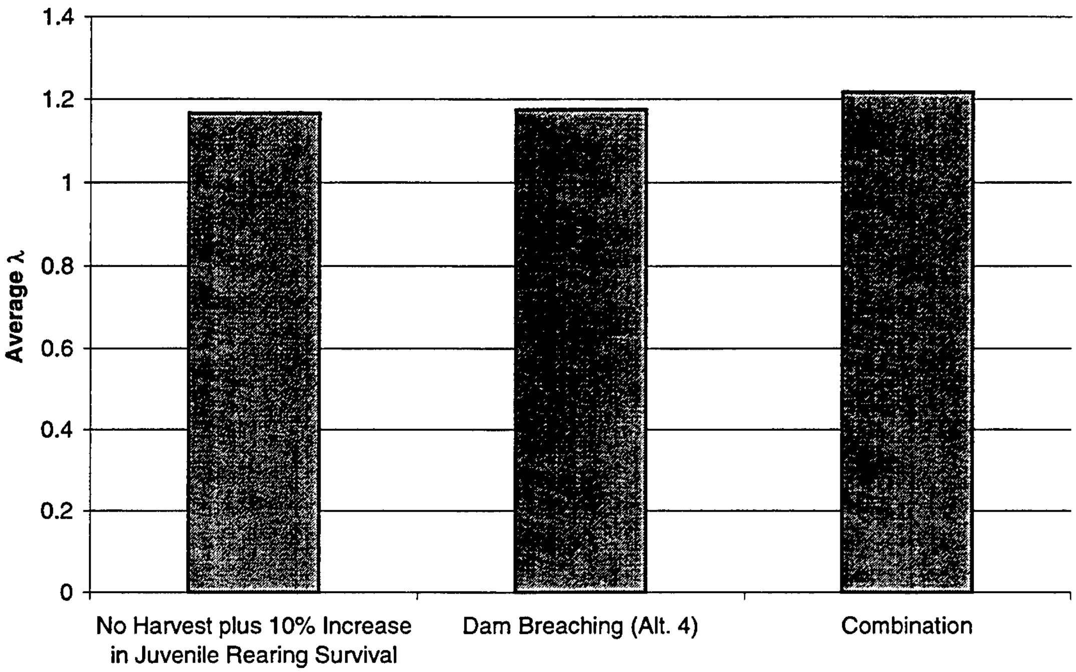
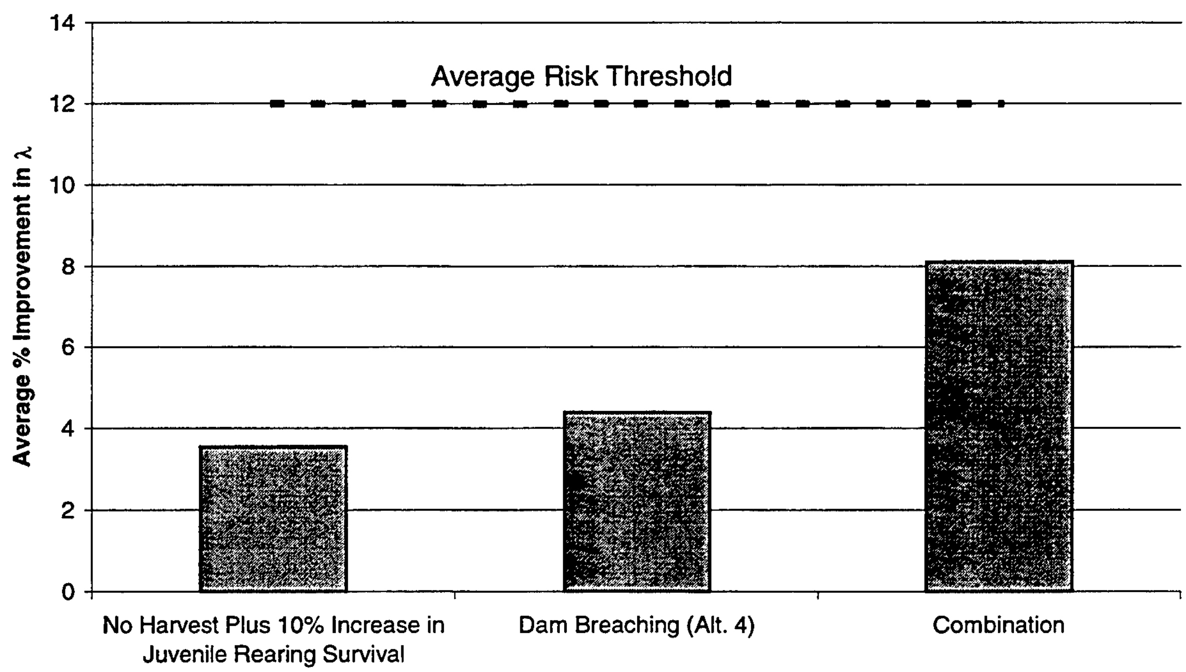


Figure 5.4-14. Average Population Growth Rate (λ), and Percent Change in Population Growth Rate Relative to Average Extinction Risk Threshold for Spring/Summer Chinook Salmon Under Hypothetical Management Scenarios





closer than either set of actions, is still less than the 12 percent recommended by NMFS to meet its risk threshold probability.

Spring/Summer Chinook Salmon Summary

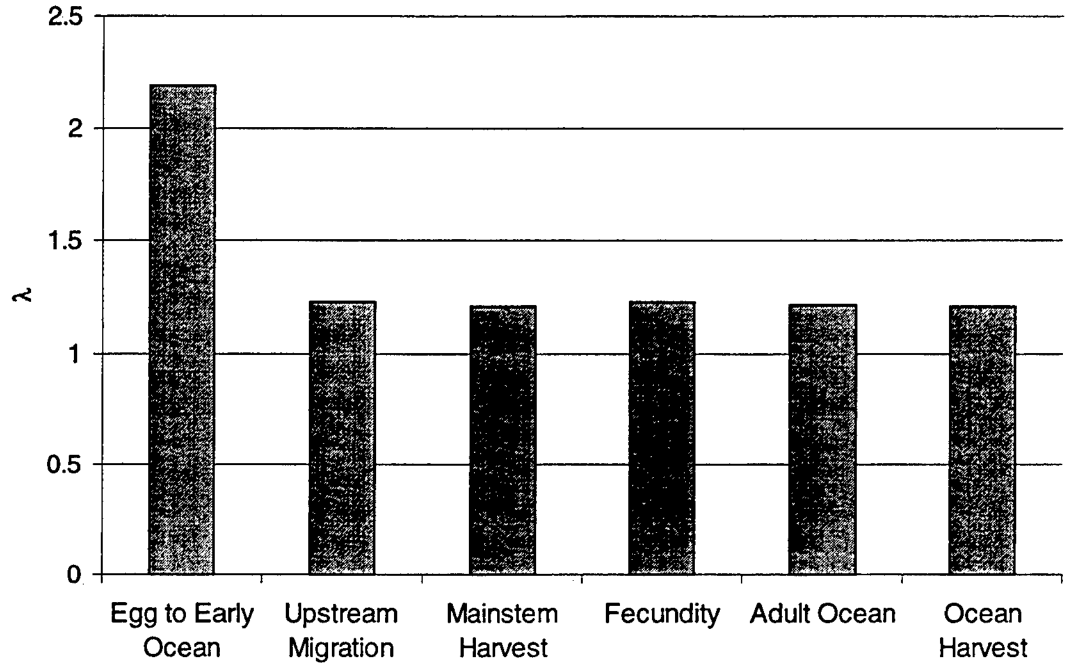
Dam breaching (Alternative 4) by itself is unlikely to meet the NMFS extinction risk threshold probability for the spring/summer chinook salmon stocks unless increased survival below Bonneville Dam, as a direct result of this removal, is increased by upwards of 60 percent. The NMFS modeling results indicated that dam breaching by itself will not recover these stocks. Also, while it is possible to generate a collection of theoretical improvements in other conditions that affect the salmonid lifecycle, the feasibility of achieving these improvements (e.g., increase juvenile freshwater habitat survival by 10 percent, increased estuarine/early ocean survival, reducing harvest to zero) are generally unknown. NMFS stated "Given the substantial risk of extinction over the short term, a totally risk averse policy would recommend dam-breaching, a moratorium on harvest, and vigorous improvements in all other areas as well." However, NMFS also indicated, alternately, managers may want to accept the 1 in 7 chance of extinction of one of the seven spring/summer chinook salmon stocks in the short term and explore whether aggressive management without dam breaching could recover the stocks. In conclusion, dam breaching is only likely to recover spring/summer chinook salmon stocks if the action has substantial effects on survival outside of the hydrosystem corridor, and important data to confirm whether this would be the case is absent.

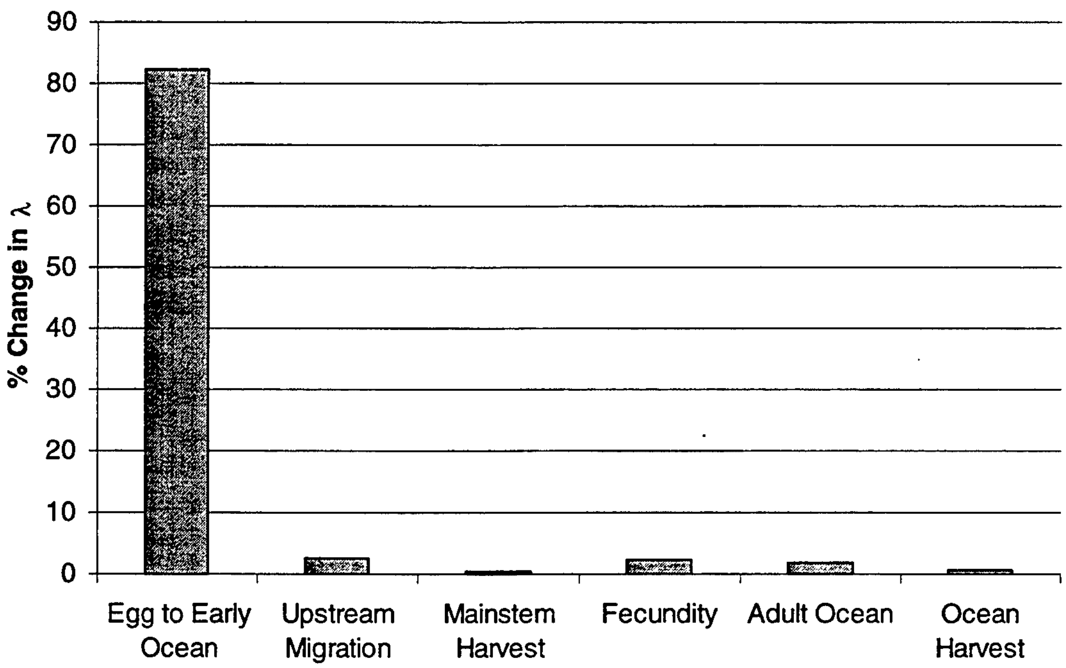
Fall Chinook Salmon

The matrix analysis for fall chinook salmon differs slightly from spring/summer chinook salmon because these two species have different life histories and harvest rates. Unlike spring/summer chinook salmon, fall chinook salmon migrate to the ocean in their first summer and spend more time rearing in the ocean. Another major difference is that fall chinook salmon have a much higher harvest rate in both the ocean and river. Also, because data on downstream survival and the proportion of juvenile fall chinook salmon transported were generally much poorer for fall chinook salmon than for spring/summer chinook salmon, NMFS combined several of the spring/summer chinook salmon life stage components for the fall chinook salmon evaluation, including early freshwater rearing, downstream migration, and estuarine/early ocean survival. These factors were considered in the matrix analysis.

The results of a sensitivity analysis, that addressed the question of what effect saving "1 in 10 fish" (10 percent reduction in mortality) by life stage, would have on annual population growth rate (λ) are presented in Figure 5.4-15. The effect of reducing mortality in the first year of life by 10 percent had by far the largest effect on population growth rate. Reducing mortality for this life stage was estimated to increase λ by over 80 percent, while a 10 percent reduction in mortality in any of the other life stages would increase λ by less than 5 percent. The first year of life includes more periods of major mortality for fall chinook salmon than for spring/summer chinook salmon. This life stage includes egg-to-smolt mortality, estuarine/early ocean mortality, and downstream passage mortality. Generally, because this life stage can encompass a large portion of

Figure 5.4-15. Population Growth Rate (λ) for Fall Chinook Salmon and Percent Change in Population Growth Rate with 10% Reduction in Mortality During Different Life Stages





potential total lifecycle mortality, saving 10 percent of these fish would include many more fish than any other modeled matrix life stage for the same rate of reduced mortality.

Based on results of the demographic matrix analysis, a reduction in harvest rates of fall chinook salmon could achieve the objective of reducing the probability of extinction to meet NMFS survival and recovery criteria. Increasing λ by only 4 percent would result in the extinction probability being reduced to the NMFS risk threshold probability level of 1 percent in 100 years. Even though harvest rates have been greatly reduced since 1993, the NMFS recommended annual population growth rate could be achieved by reducing either current ocean or mainstem harvest rates by 75 percent, or by reducing both by 50 percent each (Figure 5.4-16). Thus, harvest reduction is a biologically reasonable management option for recovery of Snake River fall chinook salmon.

Assessing the effects of Alternative 4—Dam Breaching is more difficult because there is a paucity of data on downstream passage survival and portion of fish transported. However, most benefits from this alternative would likely occur during the first year of life, which includes downstream migration and estuarine/early ocean rearing, where any latent effects (e.g., delayed transport mortality, extra mortality) of the hydrosystem may occur. Currently, the lower Snake River is primarily a migration corridor for subyearling fall chinook salmon and its use as a viable rearing area in the future is unknown. However, it could include some of the fish that have been documented to overwinter and outmigrate as yearling fall chinook salmon from this system. If this were to occur, overall smolt to adult returns for these fish may increase as indicated by the few fish that have been observed as yearling fall chinook salmon. The effects on λ from changes in survival of this life stage, for example, range from about 2.5 percent in λ for a 10 percent increase in survival, to about 16 percent for an increase in λ for a survival increase of about 80 percent (Figure 5.4-17). If dam breaching was to result in a 20 percent increase in survival for the juvenile freshwater/early ocean life stage, a 4 percent increase in λ would occur. This would achieve the NMFS threshold value of less than 1 percent chance of extinction in 100 years (Figure 5.4-17). The likelihood of this level of improvement occurring from dam breaching is unknown. However, as noted in earlier sections, dam breaching would also have the advantage of enhancing fall chinook salmon production by providing about 34 miles of additional spawning habitat suitable for an estimated 5,000 additional spawners in the newly unimpounded river reach. However, presence of spawning habitat in this reach may cause problems for native Snake River fall chinook salmon. Because of the high rate of straying that currently occurs into the lower Snake River, it is possible that these non-native stocks may utilize this newly developed spawning area, possibly mixing with native stocks and ultimately changing the genetic characteristics of the native stock.

Steelhead

There was insufficient steelhead data to conduct a demographic matrix analysis similar to the one conducted for spring/summer and fall chinook salmon. However, NMFS used the extinction analysis data, with other information, to evaluate the level of changes that would be needed to meet NMFS' recommended extinction risk threshold probability (probability of 0.01 in 100 years) as it relates to potential management actions (i.e., hydroelectric and non-hydroelectric actions). An increase in λ of about 10 percent over

Figure 5.4-16. Percent Increase in Fall Chinook Salmon Population Growth Rate (λ) Relative to an Extinction Risk Threshold over a Range of Ocean and Mainstem Harvest Reductions

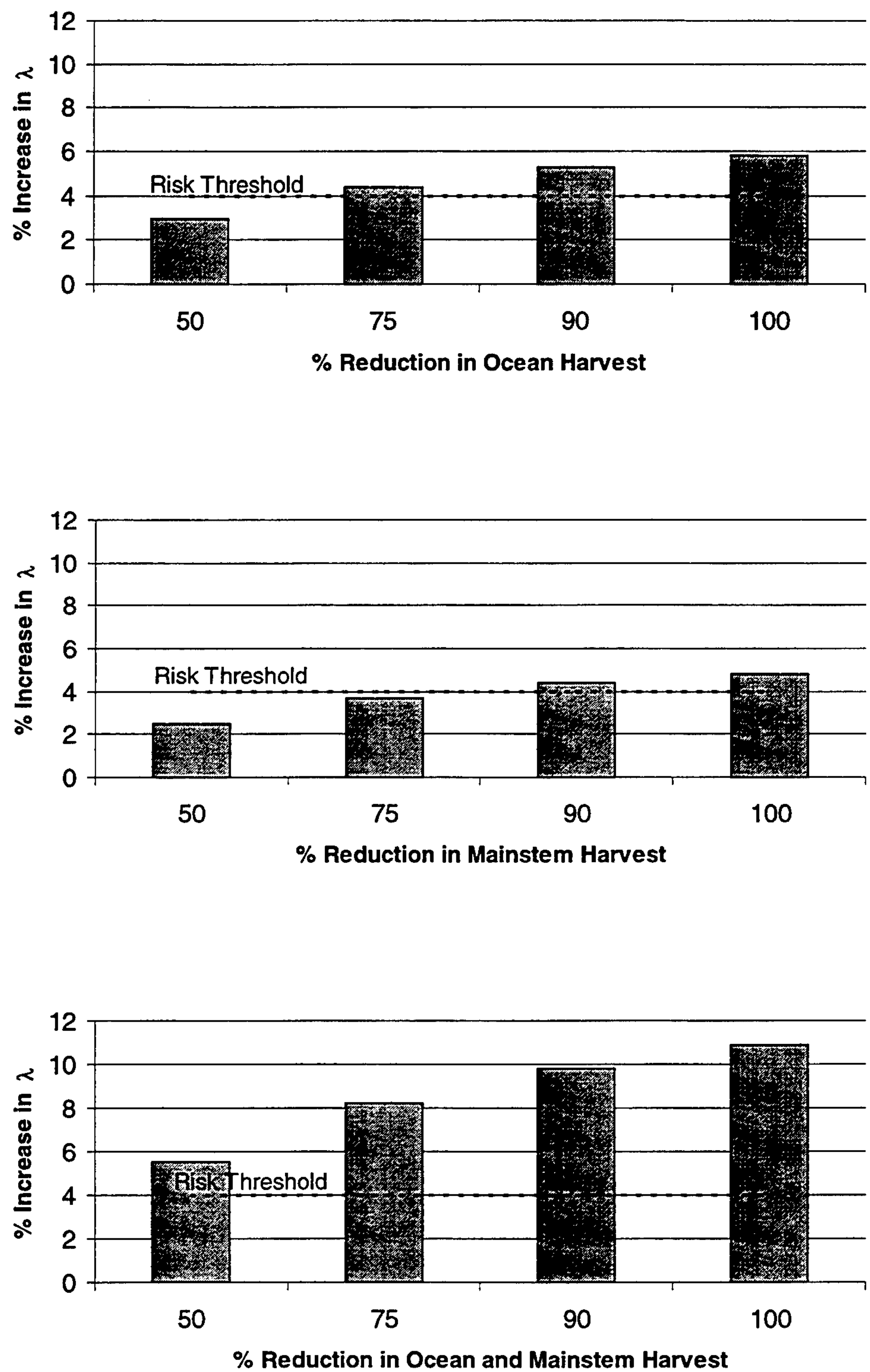
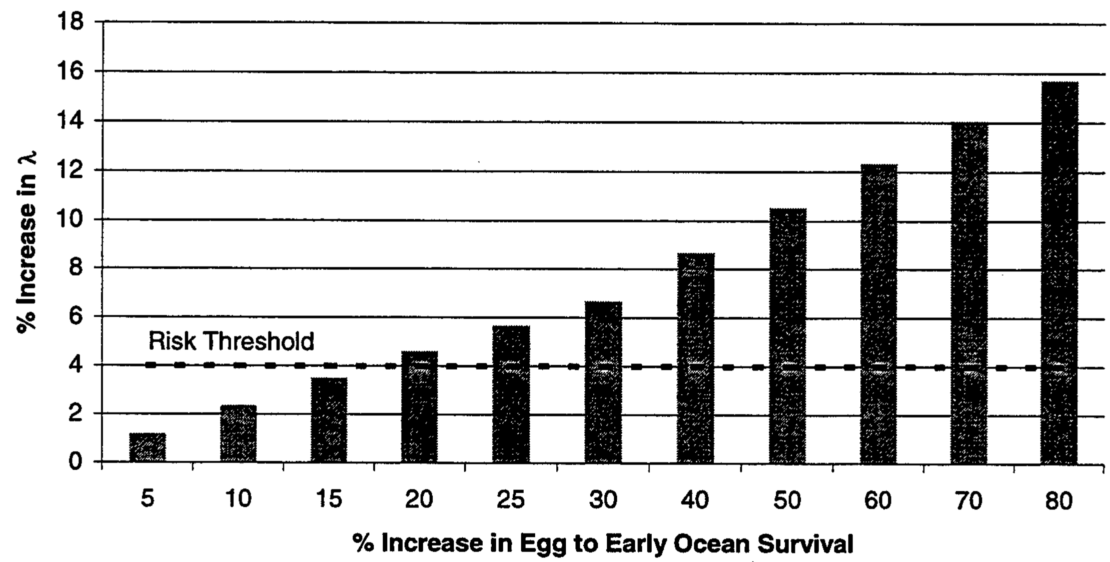


Figure 5.4-17. Percent Increase in Fall Chinook Salmon Population Growth Rate (λ) Relative to an Extinction Risk Threshold Over a Range of Relative Increases in Egg to Early Ocean (First Year) Survivals



current conditions would be needed to achieve the extinction risk threshold probability noted above (Table 5.4-11). The estimated annual population growth rate (λ) of steelhead is 0.91, indicating a decreasing population trend. The 1993-94 harvest rate estimate is about 32 percent of the adults. If harvest rate were reduced to zero, λ would increase to 0.91/(1-.32) or 1.38. This is a substantial increase (nearly 50 percent) in population growth rate. A reduction of harvest rate to only 20 percent would increase the population growth rate to 1.07. This change alone would result in the chance of extinction in 100 years decreasing to a probability of 0.001, which is within the NMFS recommended criteria to prevent extinction. It should be remembered that achieving an acceptable risk threshold for extinction may not be the same as achieving a desired escapement level that is considered acceptable for "recovery." In fact, λ may need to be greater than what is needed for acceptable risk of extinction to achieve recovery in a specified time period, but that relationship was not explored in the NMFS analysis (Technical Appendix A, Anadromous Fish). As with fall chinook salmon, a reduced harvest rate alone could reduce extinction risks of steelhead to acceptably low levels. The impact of dam breaching on steelhead is much harder to evaluate because the steelhead lifecycle is complicated and data on passage survival rates are almost entirely non-existent. By analogy to other salmonids, it is not unreasonable to assume that dam breaching, without any harvest reductions, could enhance survival by 20 percent, which would be enough to increase the annual population growth rate to levels that would produce an acceptably low risk of extinction.

Limitations of CRI Analysis and Summary

NMFS noted several limitations to the CRI analysis. Generally, the analysis does not deal directly with many of the details that are and can be analyzed by the PATH and does not account for potential changes in production with changing abundance. For example, it does not include effects of flow and individual hydrosystem changes at dams on population growth rate. Also, it does not have a mechanism for incorporating changes to the demographic matrix from specific management actions. It is also not able to incorporate factors like potential changes in ocean condition or catastrophic events. The resulting estimates of 95 percent confidence intervals of extinction risk, particularly over a 100-year period, are so broad that to make a meaningful interpretation of point estimates of extinction is potentially difficult. Also, comments on the CRI analysis point out that the probability of extinction is not equivalent to the probability of recovery, and the rate would need to be higher for λ to achieve recovery. These and other limitations are explained in more detail in Technical Appendix A, Anadromous Fish.

The CRI analysis presented by NMFS attempted to do two things. First, NMFS used the CRI to assess the current potential of short- and long-term extinction of spring/summer chinook salmon, fall chinook salmon, and steelhead, if conditions remain as they are (generally Alternative 1—Existing Conditions). Second, NMFS used the CRI analysis to put dam breaching (Alternative 4—Dam Breaching) in perspective with other potential management actions relating to harvest, habitat, hatcheries, and hydropower.

Several conclusions can be drawn from the CRI analysis:

The CRI analysis suggests that dam breaching (Alternative 4—Dam Breaching) alone is not sufficient by itself to recover spring/summer chinook salmon. Unfortunately, very few studies are available linking any of the other four Hs to changes in production. However, without more information, the best prospect to prevent short-term extinction is a combination of habitat improvement, harvest management, predator control, and dam breaching. Even with these factors, recovery is not ensured.

For dam breaching alone to recover spring/summer chinook salmon, one would need to assume very optimistic scenarios about how much survival below Bonneville Dam could be improved due to the elimination of latent mortality not measured during in-river downstream and upstream migration. For aggressive habitat management and other management actions to alone be sufficient, one would have to assume magnitudes of habitat improvements that have unknown achievablility.

For steelhead and fall chinook salmon, dam breaching alone could recover these stocks, but only if at least a 20 percent improvement in survival below Bonneville Dam occurs as a result of this action. This analysis also indicates that a harvest moratorium or reduction could have the same effect relative to recovery. Although not included in the CRI analysis, dam breaching would also increase mainstem river habitat for fall chinook salmon.

The critical uncertainty in both the CRI and PATH analysis is the level of differential delayed transport mortality and extra mortality that can be assigned to the hydrosystem. The determination of these factors strongly affects evaluation of the efficacy of dam breaching to recover spring/summer chinook salmon.

The CRI analysis, in agreement with PATH analysis, concluded that further improvements in spill, bypass systems, or transportation (e.g., Alternatives 2 and 3) are unlikely to be adequate to rebuild the listed Snake River stocks.

CRI also highlighted the potential benefits of gains in overall production from improvements in various life stage survivals (e.g., early freshwater rearing, estuary/early ocean survival) from habitat improvements or changes in management actions. Whether such changes could be implemented or would have the modeled effect is unknown.

The CRI analysis also estimated that the chance of extinction is fairly high for some spring/summer chinook salmon stocks (up to 15 percent), but low for fall chinook salmon and steelhead (less than 0.01 percent) in the short term (within 10 years). However, over the long term (within 100 years), the chance of extinction under current operating conditions is high, ranging from 33 to 88 percent for spring/summer chinook salmon index stocks, 6 percent for fall chinook salmon, and 93 percent for steelhead. The short-term probabilities provide a measure to weigh the effect of delayed action against improved information about what action to take.

5.4.2 Resident Fish

This section discusses the likely short-term and long-term effects of Alternative 1—Existing Conditions and three action alternatives to resident fish species and other aquatic fauna (see Section 3.0, Plan Formulation, for details). These action alternatives are:

- Alternative 2—Maximum Transport of Juvenile Salmon (using existing and currently planned system improvements)
- Alternative 3—Major System Improvements
- Alternative 4—Dam Breaching.

Table 5.4-12 summarizes the potential effects of these alternatives on resident fish.

Table 5.4-12. Summary of the Potential Effects of the Alternatives on Resident Fish

Alternative 1	Alternative 2	Alternative 3	Alternative 4
No detectable short-term, long-term negative, or cumulative effects are expected.	Same as Alternative 1.	Same as Alternative 1.	• Short-term negative effects could include stranding, increased predation in off-channel mitigation ponds and other embayments, changes to spawning habitat, and initial increased turbidity that could reduce feeding, growth, and reproduction and could have lethal effects for limited periods. • Long-term effects include significant changes in the amount and type of resident fish habitat, corresponding changes in the structure of the fish community that thrives in the reach, and some increased effects from flow augmentation.

Under Alternatives 1, 2, and 3, existing and currently planned system improvements would be implemented, such as extended submerged bar screen (ESBS) improvements, the replacement or rehabilitation of turbines and generators, fish separators, fish barges, adult fish attraction ladder pumps, and dewatering screens (see Table 3-1 and Section 3, Plan Formulation, for details). Under Alternative 3—Major System Improvements, additional major improvements would include a surface bypass collector (SBC) at Lower Granite Dam and new ESBSs at Ice Harbor and Lower Monumental dams. Alternatives 2 and 3 both have the objective of loading all juvenile salmonids collected from bypass systems onto trucks or barges and transporting them downstream for release below Bonneville Dam; consequently, no volunteer spill would occur under either of these alternatives except at Ice Harbor Dam. The primary difference is that a higher proportion of juvenile salmonids would be collected under Alternative 3—Major System Improvements compared to Alternative 2—Maximum Transport of Juvenile Salmon.

The system configuration for the Lower Snake River Project (all four dams) would be identical under Alternatives 1 and 2, but only a portion of the juvenile salmonids would be transported under Alternative 1—Existing Conditions according to the annual Fish

Passage Plans and the Corps' Juvenile Fish Transportation Program; the remainder would be released in the tailrace of each dam. Alternative 1—Existing Conditions includes volunteer spill (outlined in the 1995 and 1998 Biological Opinions) to reduce the proportion of fish that would pass through turbines.

Alternative 4—Dam Breaching foregoes any major system improvements, and instead breaches portions of the four dams, thereby allowing the river to be drawn down to a natural level. Under Alternative 4—Dam Breaching, water storage would continue upstream of the lower Snake River. Therefore, unlike the changes in channel morphology that would occur downstream of the confluence of the Snake and Clearwater rivers, flow releases and regimes are not expected to change and no native resident fish habitat would be recovered upstream.

Under current operating procedures, up to 1.4 million acre-feet (MAF) of water can be used from Dworshak Reservoir (Corps) and Brownlee Reservoir (Idaho Power Company) to meet target flows at Lower Granite Dam. All of the alternatives include an additional 427 thousand acre-feet (KAF) of flow augmentation during the juvenile salmonid outmigration period. These additional required flows are derived from the upper Snake River (i.e., above the Hells Canyon complex) as described in the 1995 and 1998 Biological Opinions.

The timing and source of river flows is important to both migrating juvenile salmon and resident fish populations in the lower Snake River. Dworshak Reservoir has selective-depth withdrawal structures that allow cool, deepwater outflows to be available for release downstream. In contrast, water from the upper Snake River generally does not have a cooling effect. Consequently, releases from Dworshak Reservoir during low flow years tend to moderate temperatures in the lower Snake River. The effect of using Dworshak Reservoir water is more pronounced in Lower Granite Reservoir because temperatures equilibrate as the waters mix and flow downstream. The effect is also less pronounced during normal and high flow years because of the greater proportion of upper Snake River water at the confluence with the Clearwater River.

Not all of the proposed measures are expected to affect resident fish species. The alternative analysis for resident fish would focus on measures affecting the following attributes:

- Total dissolved gas (TDG) supersaturation
- Spill and entrainment
- River level (drawdown).

Changes in these attributes are expected to have the greatest effect on the abundance and diversity of the resident fish currently inhabiting the reservoirs and habitat downstream of the project. The following sections describe how proposed measures would affect these attributes and, correspondingly, resident fish.

5.4.2.1 Total Dissolved Gas

The production and physiological effects of water supersaturated with TDG on anadromous fish are discussed in Section 4.4, Water Resources. Similar effects (i.e., gas bubble trauma) have been observed for resident fish species in the mid-Columbia River (Dell et al., 1975) and lower Clearwater River (Cachnauer, 1995) during periods of spill.

However, no resident fish collected from upper Little Goose Reservoir were observed with symptoms of gas bubble trauma (GBT) during short-duration spills from Lower Granite Dam (Bennett et al., 1994). Overall, the available information suggests that the current incidence of GBT has not resulted in detectable population changes for resident fish species.

Nevertheless, measures that would reduce the level of TDG or duration of super-saturation (when TDG levels exceed 100 percent) events would likely reduce the incidence of GBT in resident fish. Measures that would affect TDG levels or duration include the volume and duration of spill, the construction of spillway flow deflectors, and raising the elevation of stilling basin floors. Spillway flow deflectors are already installed for most spillways at the four lower Snake River dams. However, measures are being considered to determine if deflectors can be added effectively at outside spillbays where they are not currently present, and to see if deflectors at the older dams can be reconfigured to improve their efficiency (see Section 3.0, Plan Formulation).

5.4.2.2 Spill and Entrainment

Passage of juvenile salmonids and resident fish through lower Snake River dams can occur by any of three main routes: through spillways, via bypass structures (e.g., fish collection and transport facilities, fish ladders), and through turbines. In addition, intermittent releases occur when navigation locks are operated. Modifying volumes of spilled water during the outmigration season is one type of measure being considered under the various alternatives. Unfortunately, increasing spill also increases the risk of TDG to concentrations that exceed regulatory thresholds. Currently, dissolved gas concentrations are monitored closely at dam tailraces to maintain below 120 percent saturation, a criterion based upon physiological effects to salmonids, but which also appears to be adequate for resident fish. Because of this operational limit, measures with higher concentrations of spill are unlikely to have severe impacts on resident fish from GBT. In contrast, alternatives with lower levels of spill are believed to have a higher risk of mortality to resident fish from entrainment through turbines or a higher level of passage by entrainment into a bypass structure. Unlike the anadromous salmonids, the number of resident fish and any associated mortality have not been quantified for any of the three routes. Consequently, confidence in the positive or negative direction of the effect on resident fish is high, but the magnitude of the effect is uncertain.

5.4.2.3 Dam Breaching

Several different scenarios are under consideration for breaching the four lower Snake River dams and returning the river to a more natural elevation. Three scheduling scenarios are under consideration: one dam per year, two dams per year, or all dams at once. The breaching schedule would likely affect the magnitude and duration of short-term effects to water quality and erosion. The most likely schedule is two dams per year over a 2-year period. Numerous tasks (see Section 3.4, Alternative 4—Dam Breaching) would be required to implement dam breaching that would be completed prior to drawdown. Overall, it is expected that about 9 years would be required to complete the process to breach all four dams (including design, contracting, and construction). In order to minimize negative effects, many of the activities would only occur between August and March, including any required excavations, levee construction, and the

actual drawdown. In addition, substantial portions (25 to 50 percent) of the current channel length would require the addition of riprap to protect roads, railroads, and bridges which would reduce the amount of riparian zone available for restoration.

In order to describe the expected amount and type of riverine habitat available following drawdown, several models were developed (see Technical Appendix B, Resident Fish). The models used historical data representing depth, substrate, and current velocity measurements taken in 1934 at transects along the lower Snake River. Output from the models included estimated river gradient, depths, velocities, substrate types, and surface area of habitat types (assuming 24 kcfs summer flows) used for habitat-use guilds described in Section 4.5, Aquatic Resources. Substantial uncertainty exists in the results because the historic data were collected under a predominately unregulated flow regime while the future system would continue to have substantial regulation from upstream projects. Nevertheless, the results of the models are the best available information to assess the long-term effects of breaching the lower Snake River dams to resident fish.

One of the results of the geomorphological analysis was the predicted average gradient in 1-mile segments (see Technical Appendix B, Resident Fish). The overall river gradient for the lower Snake River is predicted to be fairly low (0.053 percent) and would vary little along the 140-mile reach from Ice Harbor Dam to the confluence of the Snake and Clearwater rivers (ranging from 0.051 to 0.059 percent). Consequently, no steep rapids and relatively few long pools are expected. The steepest segments having gradients greater than 0.19 percent are expected to occur between Silcott Island and Clarkston, Washington (RM 136-137), and near Texas Rapids (RM 66-67). Gradients greater than 0.09 percent are also expected near Fishhook Park (RM 16-18), between the Palouse and Tucannon rivers (RM 59-61), and below Nisqually John Landing (RM 125-127).

River depths are expected to be mostly less than 14 feet deep at the modeled flow (25 to 35 kcfs depending upon the reach), but depths are expected to occasionally exceed 25 feet near the channel thalweg. Three pools are expected near Fishhook Park (RM 14-26) interspersed with the steeper section mentioned above. Two of these pools are expected to be greater than 50 feet in depth. A third deep pool greater than 50 feet in depth is expected just upstream of the Palouse River. Other pools about 1 mile in length, but less deep are expected sporadically throughout the lower river except between RM 26 and 66, where no pools are expected.

Modeled habitat types suggest that deep, slow, or standing water habitat (Types E, F, G, respectively) would be rare in the unimpounded river and would account for little more than 2 percent of the surface area (Table 5.4-13). In contrast, over 90 percent of the surface area in-river would have velocities exceeding 2.0 feet/second (Type A). The proportional distribution of water velocities greater than 2.0 feet/second within different river reaches is depicted in Figure 5.4-18. About 30 percent of the river is expected to have relatively swift velocities greater than 5.0 feet/second (ft/sec). The most noticeable exception is the portion of McNary pool that is in the Snake River. The majority of this lower reach (73 percent) is expected to have velocities less than 2.0 feet/second resulting primarily from the low gradient. In addition to the simple habitat types, complex habitat types such as islands, braided channels, or backwaters are expected to occur in seven areas between RM 13 and RM 34, and in seven areas between RM 72 and RM 102.

Table 5.4-13. Summary of the Amount of Expected Habitat Types in a Restored Lower Snake River After Dam Breaching, Assuming Summertime 24 kcfs Flows

Snake River Segment	Surface Area (acres) Reservoir	Surface Area (acres) Riverine	Riverine Habitat Types[1/]	Individual Habitat Surface Area Acres	Individual Habitat Surface Area %
Upper McNary Arm	1,989	1,989	A	559	28.1
			B	216	10.5
			C	966	48.6
			D	91	4.6
			E	157	7.9
			F	0	0.0
			G	28	1.4
Ice Harbor	8,375	3,475	A	3,087	88.8
			B	260	7.5
			C	54	1.5
			D	70	2.0
			E	4	0.1
			F	0	0.0
			G	20	0.6
Lower Monumental	6,590	3,191	A	2,931	91.9
			B	200	6.3
			C	21	0.6
			D	40	1.2
			E	1	0.0
			F	0	0.0
			G	8	0.2
Little Goose	10,025	3,754	A	3,367	89.7
			B	283	7.6
			C	33	0.9
			D	68	1.8
			E	2	0.1
			F	0	0.0
			G	13	0.4
Lower Granite	8,900	2,742[2/]	A	2,494	91.0
			B	157	5.7
			C	42	1.5
			D	46	1.7
			E	3	0.1
			F	0	0.0
			G	11	0.4
Total Reach	**33,890**	**13,162**	**A**	**11,879**	**90.3**
			B	**900**	**6.8**
			C	**150**	**1.1**
			D	**224**	**1.7**
			E	**10**	**0.1**
			F	**0**	**0.0**
			G	**52**	**0.4**

1/ Key to riverine habitat types:
A=velocity > 2.0 ft/s; all depths.
B=velocity = 0.5-2.0 ft/s; depths < 10 ft.
C=velocity = 0.5-2.0 ft/s; depths > 10 ft.
D=velocity < 0.5 ft/s; depths < 10 ft.
E=velocity <0.5 ft/s; depths 10-35 ft.
F=velocity <0.5 ft/s; depths > 35 ft.
G=velocity <0.1 ft/s; all depths to 35 ft.
2/ Area estimate does not include section from Lewiston to Asotin.
Note: Upper McNary Pool arm shown for comparison.

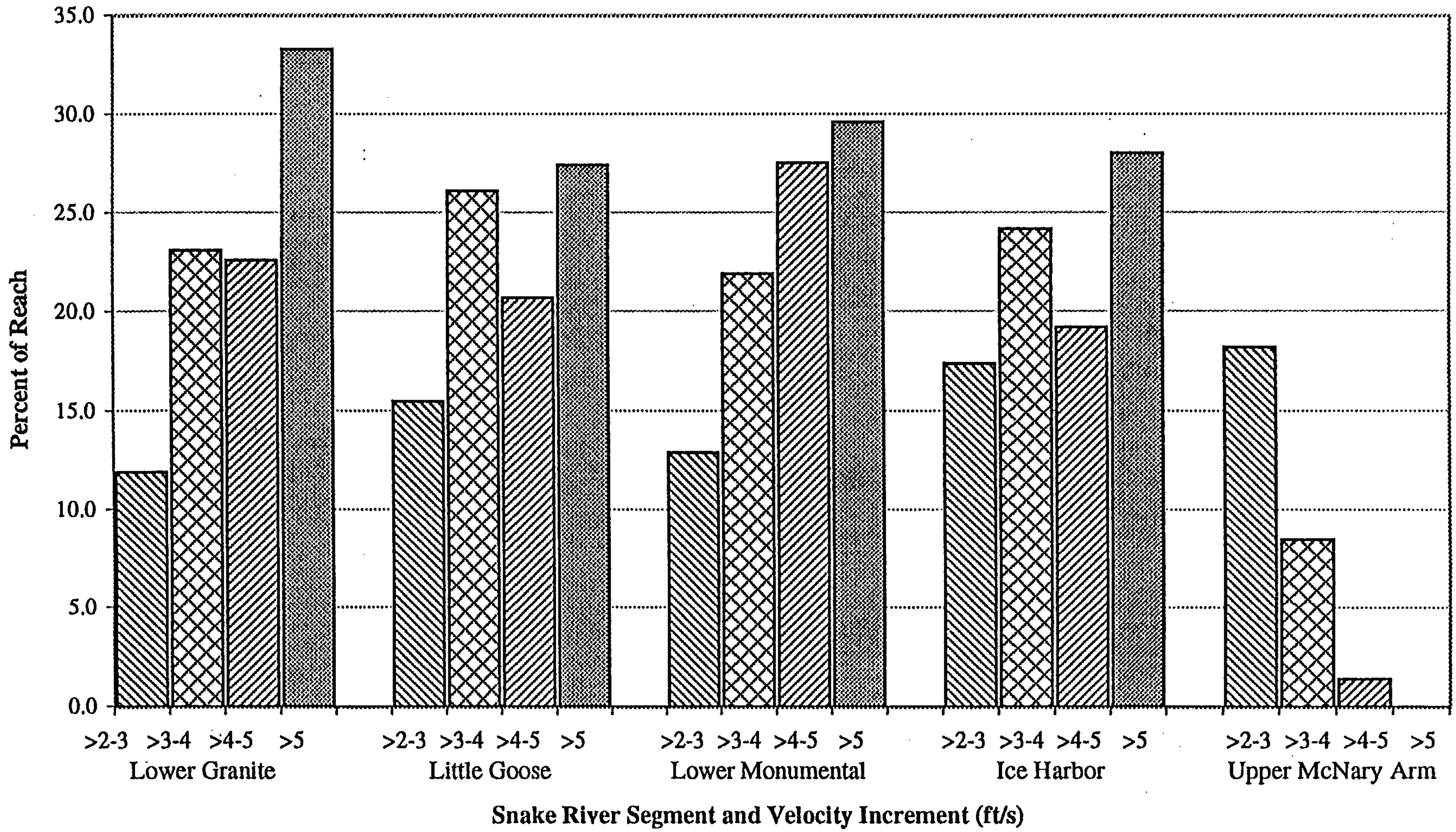


Figure 5.4-18. Proportional Distribution of Predicted River Velocities in a Restored Lower Snake River Determined by a Two-Dimensional Model

Prediction of habitat types and substrate distribution was not linked in the models. However, substrates are expected to be coarser in steeper, high-velocity sections and finer in the deeper, slower-velocity pools. Substrates in the lower river are expected to range from gravel/sand (dominant/subdominant) to bedrock/cobble. The types of substrate are expected to be more homogeneous upstream of Little Goose Dam with gravel/sand accounting for most of the reach, interspersed by short areas of bedrock/cobble or gravel/cobble. The substrate is expected to be coarser in the reach between Lower Monumental and Little Goose dams. Most of this reach is expected to include a cobble/gravel substrate interspersed by sections of bedrock/cobble and gravel/sand. The upper two-thirds of the reach between Ice Harbor Dam and Lower Monumental Dam is expected to be gravel/sand, while the lower third is expected to be a combination of cobble and gravel.

Most substrate currently in the river channel is highly embedded as a result of sediment deposition during up to 37 years of impoundment. Mobilization and flushing of the finer sediments that surround (i.e., embed) gravels, cobbles, and larger substrates could take several years of high flows (>200 kcfs). It is expected that most of the fine sediments would be deposited into McNary pool over a 5-year period following breaching of the four dams; however, some low-gradient reaches (e.g., near RM 120) could retain sediments for up to 10 years (Technical Appendix B, Resident Fish).

5.4.2.4 Effects of the Alternatives

The following sections describe the expected short-term, long-term, and cumulative effects of the alternatives to resident fish and other aquatic features. Short-term effects occur immediately because of implementing measures or within 5 to 10 years. Long-term effects could also begin shortly after implementing measures, but could have long-lasting effects on the structure of the resident fish populations. Cumulative effects include both the effects of the alternative measures and the effects of ongoing and future expected measures likely to affect the resident fish in the project area.

Alternative 1—Existing Conditions

Under Alternative 1—Existing Conditions, currently planned structural modifications to the dams would be implemented, flows and other operating procedures would continue according to the 1995 and 1998 Biological Opinions, and juvenile salmonid transport levels would continue according to annual Fish Passage Plans under the Corps' Juvenile Fish Passage Program.

No detectable short-term, long-term negative, or cumulative effects are expected from this alternative relative to the current resident fish population structure (Technical Appendix B, Resident Fish). Alternative 1—Existing Conditions has the highest level of spill of the four alternatives and consequently has the highest risk of high TDG concentrations. However, monitoring for TDG combined with the presence of spillway flow deflectors should minimize this risk below a detectable level for resident fish.

As described above and in Section 3.0 (Plan Formulation), summer flow augmentation using water from Dworshak would continue to have potential negative effects to resident fish spawning success in Lower Granite Dam, depending upon the timing, magnitude,

and duration of the releases. However, flow augmentation is included in all of the alternatives. The effects of flow augmentation are expected to be similar for Alternatives 1, 2, and 3, but different for Alternative 4—Dam Breaching as a result of river volumes. However, flow augmentation effects in Alternative 4—Dam Breaching would be small relative to other components of the alternative (dam breaching) and cannot be considered an important distinguishing factor.

Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 3—Major System Improvements

Under Alternative 2—Maximum Transport of Juvenile Salmon, currently planned structural modification to the dams would be implemented while major system improvements would be implemented under Alternative 3—Major System Improvements. Both alternatives would have flows and other operating procedures continued according to the 1995 and 1998 Biological Opinions, and juvenile salmonid transport proportion would be maximized. Higher proportions of juvenile salmonids are expected to bypass the dams under Alternative 3—Major System Improvements compared to Alternative 2—Maximum Transport of Juvenile Salmon because of the major system improvements. In order to maximize transport, spill levels would be minimized during the outmigration period.

Similar to Alternative 1—Existing Conditions, no detectable short-term, long-term, or cumulative effects are likely to occur to resident fish under Alternatives 2 and 3 (Technical Appendix B, Resident Fish). A lower level of spill could reduce the negative effects from TDG, but could include a concurrent increase in negative effects from entrainment, particularly to suckers, catfish, carp, peamouth, and white crappie. Neither of these potential sources of mortality are known to have a significant effect on the resident fish populations and community structure under current conditions. Maximized juvenile transport could reduce the salmonid component in the resident fish diets, but this is not expected to have detectable changes in resident fish demographics. In addition, potential changes as a result of Alternatives 2 or 3 are not likely to be detectable (Technical Appendix B, Resident Fish).

Alternative 4—Dam Breaching

Implementation of Alternative 4—Dam Breaching would result in breaching the earthen portions of the four lower Snake River dams, resulting in a 140-mile unimpounded reach. Of the four alternatives, Alternative 4—Dam Breaching is expected to have the largest effect on the current resident fish community structure. The short-term negative effects to resident fish are expected to result from rapid lowering of the water surface elevation and high turbidity. In contrast, the long-term effects would result from major changes in the amount and type of resident fish habitat present in the reach and a higher magnitude effect of flow augmentation.

Short-term Effects

Rapidly lowered water surface elevations are expected to have the largest unavoidable short-term effect on resident fish. Current plans call for lowering reservoir levels about

2 feet per day. For Lower Granite, the deepest of the four reservoirs at the dam, this represents about an 8-week drawdown period. During this period, off-channel mitigation ponds, backwaters, and other embayments would drain, leaving many fish stranded. Areas with shallow impoundments would become stagnant and eventually subject to desiccation. A temporary drawdown of Lower Granite Dam in 1992 resulted in the stranding of an estimated 15,000 fish. Negative effects of stranding were highest for largemouth bass (Schuck, 1992). Overall, the short-term effects are expected to be most severe for those species and life stages that prefer shallow, low-velocity habitat types. These species include largemouth bass, crappie, sunfish, yellow perch, carp, bullheads, and the juvenile life stage of northern pikeminnow and smallmouth bass.

An indirect effect of lowered water surface elevations would be changes in the availability and density of forage. Concentrations of predators and prey in smaller volumes of water can result in increased predation levels. Increased predation from birds and other fish on prey items in mitigation ponds was observed during the Lower Granite Reservoir test drawdown (Schuck, 1992) and should be expected under Alternative 4—Dam Breaching. One additional negative effect expected is the stranding and loss of crayfish that are an important source of food for several of the resident fish species.

Water velocity is expected to increase as water surface elevations drop and accumulated sediments along the banks and bottom of the reservoirs are expected to erode and contribute to turbid flows. Erosion is expected to be particularly high at deltas that form at the mouth of the rivers and streams draining into the lower Snake River. As water levels drop, new channels would be cut through sediment deposits as fluvial processes re-establish a fluvial river morphology. During the initial 15-year period, coarse substrate would become exposed and potentially available for spawning salmonids, including resident salmonids. However, the quality of spawning habitat could be low in some areas until substantial amounts of previously deposited sands and fines are transported downstream and a more natural sediment regime develops.

The severity of suspended sediment effects is related to its concentration and duration of exposure to fish (Newcombe and Jensen, 1996). Sub-lethal effects to warm-water fish that reduce feeding, growth, or reproduction have been observed at concentrations ranging from 62.5 to 144.5 mg/l experienced over a period of 30 days (Buck, 1956, as cited in Newcombe and Jensen, 1996). In contrast, Wallen (1951) (cited in Newcombe and Jensen, 1996) observed only limited behavioral effects up to concentrations of 20,000 mg/l and acute lethal effects above 175,000 mg/l. Lethal events usually occur by suffocation because gills become coated with sediment. Overall, it appears that resident fish can withstand moderate to high turbidity, at least for short periods.

The magnitude of turbidity expected during the drawdown period is not known with certainty. However, as a reference point, the 1992 drawdown test of Lower Granite Reservoir, produced suspended sediment observed up to 2,000 mg/l (Technical Appendix C, Water Quality). Suspended sediment is expected to be highest during the first year following breaching and decline thereafter. The magnitude of peak spring flows and its timing relative to the breaching schedule can affect the severity of erosion. Peak flows for a high water year or heavy rainfall following breaching could cause a higher magnitude of erosion because vegetation would not have had sufficient time to become established.

For the current analysis, sediment models were developed for predicting the number of days per year that suspended sediment would exceed 25 mg/l (Technical Appendix C, Water Quality). This criteria was used for SOR (BPA et al., 1995) and was selected for protecting salmonids based upon a review of pertinent literature. During the first year following dam breaching, suspended sediment levels were predicted to exceed the 25 mg/l criteria approximately 131 days. During the following 15 years, sediment levels were predicted to exceed the criteria an average of 91 days per year. Based upon the experience from the Lower Granite Reservoir drawdown test and suspended sediment modeling, lethal effects are expected to be localized and infrequent while sub-lethal effects could affect growth and year-class strength of resident fish for several years following dam breaching (Technical Appendix B, Resident Fish).

Long-term Effects

While the effects of sediment suspension from channel cutting are expected to decline and substrates are expected to become coarser following dam breaching, the development of a new channel morphology and fish habitat characteristics would have long-lasting beneficial effects on the community structure of native resident fish. Although it is unlikely that introduced fish species would disappear, their prevalence is expected to decline. Overall, the community is expected to have higher representation of the high velocity riverine species historically present in-river while habitat generalists such as smallmouth bass are also expected to persist and thrive under natural river conditions. Similarly, the food web would be based more upon attached and drift forage species (benthic algae, mayflies, caddisflies, etc.) rather than emergent vegetation, phytoplankton, zooplankton, and benthic forage species (earthworms, mussels, etc.).

No quantitative information is available on the fish community in the lower Snake River prior to construction of the four dams. Consequently, information from the unimpounded reach of the Snake River above Asotin is presented to provide some indication of how biomass might change if Alternative 4 is implemented (Table 5.4-14). The data in Table 5.4-14 should be viewed with the understanding that biomass is depicted in units of pounds per mile of river length and pounds per acre (standing crop). Total biomass on a per mile basis is likely to decline by more than half under free-flowing conditions. However, total standing crop would increase by more than half.

This apparent discrepancy results because the surface area of the lower Snake River would decrease from 33,236 acres to 19,464 acres, a decline of 58 percent. Consequently, if the total weight of a species declined by less than 58 percent, standing crop would increase even though the linear biomass declines. Caution is also warranted because river conditions downstream of Asotin are substantially influenced by the Clearwater River. In particular, water temperature regimes could be markedly different between the two reaches, especially during low flow years.

In contrast to fish community changes predicted in Technical Appendix B (Resident Fish), a study by Petersen et al. (1999) suggests that smallmouth bass abundance will decline by half and northern pikeminnow abundance will double if Alternative 4 is implemented. The two studies conclude opposite effects for these two species. Consequently, there does not appear to be scientific consensus on how dam breaching will affect the resident fish community.

Table 5.4-14. Comparison of Estimated Biomass for Native and Introduced Fishes in the Free-flowing Snake River above Asotin and in Lower Granite Reservoir

	Free-flowing Snake River		Lower Granite Reservoir		Areal Change	Linear Change
Species	**lbs/acre**	**lbs/mi**	**lbs/acre**	**lbs/mi**	**(%)**	**(%)**
Native						
Sucker spp.	37.4	2,116.0	25.4	5,799.9	47	-64
Northern pikeminnow	7.1	403.1	3.1	712.1	129	-43
Chiselmouth	5.3	302.3	4.5	1,017.6	20	-70
White sturgeon	4.5	251.9	0.4	77.3	1,150	226
Peamouth	1.8	100.8	2.7	610.6	-33	-83
Mountain whitefish[1/]	2.7	151.1	0.1	22.4	2,900	576
Rainbow trout[1/]	1.8	100.8	NA	NA		
Redside shiner	0.9	50.4	NA	NA		
Bull trout[1/]	0.1	5.0	NA	NA		
Other cyprinids; sculpins	2.2	126.0	0.3	61.0	733	106
Non-native						
Common carp	3.6	201.5	1.6	360.1	122	-44
Smallmouth bass	6.2	352.7	0.9	207.6	600	70
Catfish/bullheads	1.3	75.6	2.5	573.7	-46	-87
Crappie spp.	0.1	5.0	0.3	67.1	-67	-93
Other centrarchids[2/]	0.4	25.2	1.2	264.7	-62	-90
Yellow perch	NA	NA	2.6	580.1		
Total	**75.4**	**4,267.2**	**45.3**	**10,354.1**	**66**	**-59**

[1/] Seasonal residents

[2/] Pumpkinseed, bluegill, warmouth

Source: Technical Appendix B, Resident Fish

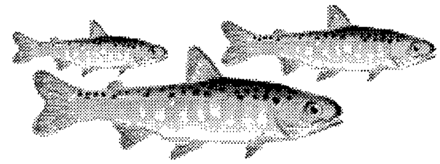
The type of effects (delay and disruption of spawning, reduced growth) from cold-water flow augmentation from Dworshak Reservoir under Alternative 4—Dam Breaching would be similar to Alternatives 1, 2, and 3. However, the magnitude of the effects could be higher under drawdown conditions because smaller water volumes in the lower Snake River would reduce the heat capacity currently available in the reservoirs. Consequently, cold-water releases from Dworshak Reservoir under Alternative 4 are expected to result in lower water temperatures that persist further downriver compared to the other alternatives, particularly under low-flow conditions (Technical Appendix B, Resident Fish; Technical Appendix C, Water Quality).

In summary, the long-term changes in the habitat types, temperature regime, and forage base are expected to result in declines for crappies, peamouth, pumpkinseed, bluegill, yellow perch, bullheads, and largemouth bass. In contrast, species expected to benefit from more natural river conditions include chiselmouth, redside shiners, speckled dace, suckers, sculpin, white sturgeon, northern pikeminnow, and smallmouth bass. The one species not expected to have a large change in density is channel catfish (Technical Appendix B, Resident Fish). Mountain whitefish, rainbow trout, and bull trout are expected to increase their utilization of the lower Snake River on a seasonal basis,

especially if water temperature fluctuation rates and peak magnitudes can be lowered. Naturally high water temperatures from mid-summer to early-fall are expected to create unsuitable habitat for these species during that period.

5.4.2.5 ESA-listed Resident Fish Species

Alternatives 1, 2, and 3 are not expected to have any effect on bull trout. In contrast, Alternative 4—Dam Breaching is expected to have a small but beneficial effect on bull trout. Similar to the other resident salmonids, bull trout can be expected to increase their seasonal use of the lower Snake River. It is unlikely that year-round residency would occur because water temperatures are expected to naturally exceed bull trout temperature requirements during summer months. Discussion of the effects of the alternatives on other ESA-listed fish species is provided in Section 5.4.1, Anadromous Fish.



5.5 Terrestrial Resources

A summary of potential effects of the alternatives on vegetation and wildlife is presented in Table 5.5-1.

5.5.1 Vegetation

This analysis of impacts on terrestrial resources is based on several assumptions. First, the effects are summarized using two time periods–short term and long term. These time periods are not mutually exclusive nor do they represent the same span of time for every habitat type or species group. They are simply a tool to present general trends in effects over time. In general, the dividing line between short term and long term for vegetation was 10 years, and the threshold for wildlife species was 5 years (approximate period of construction). Again, this is not meant to be a strict definition. Second, this analysis assumes that irrigation will be maintained on those Habitat Management Units (HMUs) that currently have it. Finally, under a drawdown scenario, this analysis assumes that the Corps will initiate extensive vegetation management to maximize the growth of native species. This effort would include physical and chemical control of noxious weeds, native willow plantings, and erosion control measures on the newly exposed islands.

Table 5.5-1. Summary of Potential Effects of the Alternatives on Terrestrial Resources

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Vegetation	No change from current conditions.	No change from current conditions.	No change from current conditions.	• Short term (< 5 years) losses of some habitat types, including forbland and planted grassland, mesic shrub, palustrine forest, palustrine scrub-shrub, and emergent wetlands would be expected (Table 5.5-2). • Almost all of these short term habitat losses would be expected to be overcome by long-term (30 to 50 years) restoration of pre-inundation habitat acreages, with the exception of palustrine emergent wetlands and ponds, which are currently more widespread than pre-impoundment (Table 5.5-2). • If Alternative 4 is chosen, an aggressive vegetation management plan would be created to manage for the predicted flush of noxious weeds and exotic species that would be released on approximately 13,772 acres of newly exposed soils.
Wildlife	No change from current conditions.	No change from current conditions although fewer fish in the river could reduce prey for some bird species.	No change from current conditions although fewer fish in the river could reduce prey for some bird species.	• Short-term loss of wetland and riparian habitats (Table 5.5-2) would have negative effects on some species, particularly amphibians, reptiles, small mammals, and deer. • Increased edge effect along old shoreline would have short-term negative effects on game birds. • Loss of open water habitat would have short-term negative effects on waterfowl. • Increased mudflats and open islands would have short-term positive effects on shorebirds and colonial-nesting birds. • Long-term positive effects on most wildlife groups through the expected development of a more contiguous riparian zone and increased area of other habitat types, such as shrub-steppe and grassland.

5.5.1.1 Alternative 1—Existing Conditions

Under Alternative 1—Existing Conditions, the existing operating system would remain the same and, therefore, no changes would be expected in vegetation communities. In the future, however, vegetation communities could change in response to management activities on HMUs and other project lands, natural vegetation development along

reservoir shorelines, and acquisition of additional project lands along the lower Snake River.

Riparian Mosaic/Emergent Wetland Communities

The amount of riparian mosaic and emergent wetland communities is not anticipated to change in the future since most of the previously planted riparian mitigation areas have matured and the Corps has met the acreage requirements for habitat acquisition approved under the Lower Snake River Fish and Wildlife Compensation Plan (Comp Plan).

Future reservoir operations may increase or decrease riparian mosaic and emergent wetland communities within the study area depending on timing, duration, and frequency of water level changes. Any future changes in riparian areas are expected to be dependent on reservoir operations, ecological factors, and irrigation of HMUs. Additionally, development of emergent wetland habitat may occur due to sedimentation near the mouth of the main tributaries, and within some of the backwaters, impoundments, and other shoreline areas of the reservoirs (Downs et al., 1996). Little, if any, changes in amounts of emergent wetland vegetation would be expected elsewhere under current reservoir management, unless wetland management activities are initiated on project lands. Future changes in mesic perennial forb and grassland communities are expected to be relatively minor; however, this will be dictated by land management activities.

Upland Community

Acreages of upland habitats are not expected to change substantially in the future under the current operations since no new acquisitions of lands by the Corps are anticipated. Additionally, agricultural land acreages should remain about the same since the Corps is already attempting to achieve optimal agricultural benefits for wildlife based on the Habitat Evaluation Procedure (HEP). It is unlikely that any additional expansion of wildlife lands will occur. The quality of vegetation of upland range habitat would likely improve over time as grazing restrictions are continued, and habitat continues to improve. These grazing restrictions currently include limiting cattle access to existing shorelines except through 60 fenced cattle corridors.

5.5.1.2 Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 3—Major System Improvements

Under these alternatives, the transport of juvenile salmon by truck and barge would be maximized (Alternative 2—Maximum Transport of Juvenile Salmon) and major system improvements would occur (Alternative 3—Major System Improvements). These actions would not cause significant changes in existing water levels on the lower Snake River, or cause any additional ground-disturbing activities on study area lands. Therefore, no measurable short-term effects to vegetation resources should occur and the long-term effects would be limited to the continued development of existing habitat.

5.5.1.3 Alternative 4—Dam Breaching

Alternative 4—Dam Breaching would result in the drop of the average surface water levels from between 94 feet below minimum operating pool (MOP) at Ice Harbor to 110 feet below MOP at Lower Granite. The river drawdown would create 140 miles of free-flowing river, exposing approximately 13,772 acres of bare substrate (mainly silt and sand) in the process. Associated dam decommissioning activities such as stockpiling and haul road construction, subsequent diversion dam construction, and shoreline stabilization efforts would also impact lands within the project boundaries.

Dam breaching would have both short- and long-term effects on riparian and wetland areas. Most of these habitat types within the project boundaries are supported by the hydrologic regimes (water levels) associated with current dam operations. Therefore, dam breaching would likely cause rather large-scale short-term effects (potential losses/changes) to existing vegetation communities. These short-term effects are more easily identifiable due to existing knowledge of current environmental conditions and proposed actions, and current studies associated with this FR/EIS.

Despite the extensive revegetation measures that would be implemented by the Corps if Alternative 4—Dam Breaching were chosen (see Annex K of Technical Appendix D, Natural River Drawdown Engineering), some unavoidable adverse impacts to plant communities would occur in the short term, including direct loss due to scouring and sluffing and indirect loss due to competition from exotic species. These effects are described in more detail below.

The long-term effects to vegetation communities are more difficult to determine, and can only be inferred through historical conditions data, professional judgement, and limited research involving test drawdowns studies within the study area. Although it appears that short-term losses of wetland and riparian communities would occur initially after dam breaching, in the long-term, under the natural river condition and land management measures proposed by the Corps under this alternative, increases in the amount or quality of wetland and riparian habitat would likely result. Various factors including biological, physical, and hydrologic conditions, and land management decisions would dictate these future vegetation communities.

Riparian Mosaic and Emergent Wetland Zones

Short-term Effects

Dam breaching would result in the loss and subsequent conversion of much of the existing shoreline riparian and wetland vegetation to upland vegetation. Plant species in riparian zones that would be particularly sensitive to drawdown include shallow rooting plants such as willows, false indigo, and white alder. Areas of the existing riparian zone that would likely be retained after dam breaching would include riparian areas along tributaries, streams, seeps, springs, and the irrigated HMUs. Additionally, small amounts of well-established riparian areas dominated by more drought-tolerant riparian plant species may be retained in areas associated with higher precipitation levels in the study area (nearer to the mouth of the Snake River). Retention of riparian vegetation associated with the established HMUs would depend on future irrigation practices by the

Corps; termination of these practices would result in the loss and subsequent conversion of most of these riparian areas to upland habitats.

Lower water levels that would occur under dam breaching would result in the loss of most emergent wetland areas associated with current embayments, backwaters, other still-water areas, and fringe areas along the reservoir and island shorelines (353 acres). Most wetland-associated areas would succumb to desiccation quickly (Corps, 1994).

The types (i.e., native/non-native) and species of plants that would initially colonize the approximately 13,772 acres of mudflats after dam breaching would mainly be dictated by the distribution and species of seed stocks within the substrate in the exposed areas, the presence of wind/water-borne seeds, and hydrologic conditions. Robberecht (1998) found that there is a sufficient seed bank in the shallow areas of the reservoirs (i.e., less than 15 feet water depth) to allow for rapid colonization of exposed banks. Below that depth, the viability and abundance of seeds diminishes, and active restoration of the desired plant community will be required.

Existing stands of purple loosestrife, a non-native invasive plant species, would likely decline significantly immediately after dam breaching because it is a wetland-associated plant. However, newly exposed, low-gradient shorelines would provide habitat for this species that may accelerate the development of purple loosestrife (Thompson, 1989).

Findings from a seed bank study performed in exposed river areas in the project area during the test drawdown (Robberecht, 1998) suggest that plant communities would develop rapidly on newly exposed shorelines above 15 feet water depth without active restoration or other types of vegetation management. Furthermore, it was suggested that newly established plant communities would likely be initially composed of native herbaceous species. However, it is important to note that significant amounts of non-native plant species seeds were identified within the substrates in the exposed areas. Due to the presence of these exotic species, and the potential for wind/water-dispersed invasive plant seeds within the project area, it is possible that non-native species would revegetate and dominate the exposed mudflats. Some of the more widespread exotic plant species identified by Robberecht (1998) include prickly lettuce, puncture vine, curly dock, common yellow sweetclover, water-cress, Russian thistle, and bull thistle. Factors such as river fluctuations, precipitation, and groundwater would also influence floral compositions.

Portions of the exposed areas may need to be irrigated, and actively managed using chemical and physical removal of non-native species, after drawdown to ensure native species establishment (Robberecht, 1998). To encourage the development of native vegetative communities and reduce soil erosion due to wind and rain, the Corps has developed a reservoir management plan. The plan includes initial seeding during the dam breaching period, reseeding and manual placement of woody species during the following year to vegetate areas where seeds did not take during the initial seeding, and annual vegetation management for a period of 10 years (Technical Appendix D, Natural River Drawdown Engineering). This plan includes an aggressive noxious weed control management program to control the spread of these plants in the newly exposed soils after drawdown.

Long-term Effects

The success of long-term establishment of vegetation communities would be mainly determined by the frequency and duration of inundation in the floodplain, land management actions (including restoration), and the presence of and distribution of invasive plant species in and associated with the exposed areas. Additionally, future vegetation communities would be influenced by factors such as the distribution, composition, and fate of existing sediments following dam breaching.

Based on historical area of riparian habitats along the lower Snake River (3,285 acres; Table 4.6-1 in Section 4.6, Terrestrial Resources) an increase in riparian mosaic habitats would result from dam breaching, and a decrease in emergent wetland habitat would occur, unless emergent wetland restoration and establishment measures are undertaken. HEP analyses calculated that the long-term gain in riparian habitat with dam breaching would be 1,481 acres (Table 5.5-2). Conditions of the exposed areas should be more conducive for quality riparian and riparian mosaic development since soils would be deeper and more productive than the rocky, shallow soils along most of the current reservoir shorelines. Also, shoreline slopes should be flatter than the current steep slopes which may support conditions more conducive to riparian and wetland habitat development. Additionally, river processes (erosion, nutrient storage and transport, and deposition) associated with the free-flowing river should produce conditions favorable for the development of quality riparian and wetland habitats.

The released sediments that lie behind the current dam structures, in association with sediment deposition along newly exposed shorelines resulting from dam breaching, may create conditions conducive to the development (elevated substrate) of emergent wetland habitats or riparian habitats in downstream portions of the lower Snake River. Much of the sediment that would be released after dam breaching would likely be deposited in the McNary pool near the mouth of the Snake River (Technical Appendix C, Water Quality). Small wetland and riparian habitats may be supported on any newly formed islands resulting from sediment deposition. However, it appears that the majority of the sediment would likely be contained and deposited within the main river channel within the impoundment. If this occurs, due to the depth of the McNary pool (>20 feet), most of the sediment would lie well below the waterline and, therefore, would not result in significant increase of potential wetland or riparian habitats.

Upland Community

Short- and Long-term Effects

Shrub-steppe and grassland habitat acreages would increase under Alternative 4 as current water levels drop within the river, and much of the existing riparian areas convert to upland habitats. Approximately 12,440 acres would be expected to return to upland habitat. The vegetation plan that would be implemented by the Corps following drawdown would include seeding of upland grasses.

Table 5.5-2. Estimated Short-term Habitat Losses and Long-term Habitat Gains in the Study Area Under Alternative 4—Dam Breaching

Habitat Type	Short Term Losses [1/] (acres)	Long Term Gains [2/] (acres)
Upland		
Cropland and Pasture	0.00	4,336.20
Grassland	0.00	3,852.30
Forbland and Planted Grassland	462.50	1,265.20
Shrub-steppe	0.00	2,342.60
Exposed Rock and Rock Talus	0.00	642.90
Total Upland Habitat	***462.50***	***12,439.20***
Riparian		
Mesic Shrub	324.30	85.20
Palustrine Forest	272.30	251.70
Palustrine Scrub-shrub	592.30	1,144.30
Total Riparian Habitat	***1,188.90***	***1,481.20***
Wetland		
Palustrine Emergence	353.20	0.00
Palustrine Open Water (ponds)	315.70	0.00
Total Wetland Habitat	***668.90***	***0.00***
Reservoir/River [3/]	**13,772.00**	**0.00**
Total Project Lands	**2,320.30**	**13,920.40**

1/ These are gross numbers. They do not factor in potential mitigation through maintenance of irrigation in HMUs or continued development in XYZ lands (see Technical Appendix L, Lower Snake River Mitigation History and Status for more information).

2/ Long term gains are based on the assumption that habitats will return to their pre-project distribution. It does not assume that HMUs or XYZ lands will be maintained. Exact distribution of habitat types following drawdown is not quantifiable.

3/ Not included in the total.

Source: HEP Analyses, 1995

Haul roads and stockpile areas associated with dam decommissioning would disturb approximately 2,000 acres of the existing upland habitat in the short term. Most of this area would likely revegetate over time; however, the roaded portions (approximately 70 acres of impact, based on a 30-foot right-of-way) are likely to remain unvegetated in the long term. To avoid possible damage by cattle to habitat and spawning areas along the new river, new cattle corridors would be grouped where possible, and wells would be installed that would provide water via solar powered pumps to stock watering tanks (for more detail, see Technical Appendix D, Natural River Drawdown Engineering). Upland habitats elsewhere in the project area would likely improve as cattle continue to be fenced out of project lands, and as habitat continued to recover. Agricultural land acreages should not increase in the future as the Corps is attempting to achieve optimal agricultural benefits for wildlife based on HEP. Most of this increase would help meet upland gamebird habitat requirements.

5.5.2 Wildlife

This analysis of impacts on terrestrial resources is based on several assumptions. First, the effects are summarized using two time periods – short term and long term. These time periods are not mutually exclusive nor do they represent the same span of time for every habitat type or species group. They are simply a tool to present general trends in effects over time. In general, the dividing line between short and long term for vegetation was 10 years, and the threshold for wildlife species was 4 years (period of construction). Again, this is not meant to be a strict definition. Second, this analysis assumes that irrigation will be maintained on those HMUs that currently have it. Finally, under a drawdown scenario, this analysis assumes that the Corps will initiate extensive vegetation management to maximize the growth of native species. This effort would include physical and chemical control of noxious weeds, native willow plantings, and erosion control measures on the newly exposed islands.

In general, the short-term and long-term effects of Alternatives 1, 2, and 3 on wildlife would be expected to be minimal because structural and management changes proposed under these alternatives are targeted specifically at juvenile salmon and would not substantially modify water levels of the reservoirs. The only alternative that would be expected to have significant effects on terrestrial wildlife would be Alternative 4—Dam Breaching. This alternative would be expected to have short-term negative impacts and long-term positive effects compared to Alternative 1—Existing Conditions. These effects are described in more detail below.

5.5.2.1 Alternative 1—Existing Conditions

Alternative 1—Existing Conditions would be expected to have little or no significant short- or long-term impacts on terrestrial wildlife resources within the study area. Continued operation of the Lower Snake River Hydropower Project would be expected to maintain current habitat conditions. For instance, the current lack of mature riparian vegetation along the river would continue. However, the size and structural complexity of the vegetation that does exist would be expected to slowly improve, which would be expected to indirectly benefit wildlife such as cavity-nesting species by providing additional nesting and foraging habitat. Riparian and upland habitat in the irrigated HMUs would be expected to continue to slowly improve. Problems with exotic species and disease would be expected to persist.

Under Alternative 1—Existing Conditions, the Corps would proceed with completion of its terrestrial wildlife mitigation requirements for the original construction of the Lower Snake River Project. Despite extensive land purchases and intensive development (e.g., irrigation and habitat improvement) of selected HMUs, the Corps is still approximately 21,000 habitat units (HUs) short of meeting California quail habitat requirements. The Corps is also short by lesser amounts of HUs for other species including the downy woodpecker, yellow warbler, ring-necked pheasant, and Canada goose (Technical Appendix L, Lower Snake River Mitigation History and Status [Table 3]). However, this imbalance would be reduced as conditions of mitigation lands continue to improve into 2000 managed as compensation for quail and pheasant hunting opportunities lost by inundation of the reservoirs (see Technical Appendix L, Lower Snake River Mitigation History and Status). Currently, work is being initiated to start a final HEP evaluation to

determine the HU status of the terrestrial wildlife portion of the Comp Plan. BPA, through the Northwest Power Planning Council, has agreed to assume responsibility, with coordination with the Corps, for the terrestrial wildlife portion of the Comp Plan, based on this formal HEP analysis, once that evaluation is complete.

If existing conditions continue, and the number of salmon returning to spawn in the lower Snake River and in other rivers and streams farther upstream does not increase, some wildlife species could suffer potential long-term, indirect negative effects. For instance, any grizzly bears reintroduced into central Idaho might be indirectly negatively affected by a lack of salmon prey during certain times of the year (Hilderbrand et al., 1996). However, the USFWS believes that sufficient alternative sources of food, such as kokanee salmon and trout, as well as herbaceous forage, are available to offset the reduced availability of salmon in the region (see Technical Appendix M, Fish and Wildlife Coordination Act Report).

5.5.2.2 Alternative 2—Maximum Transport of Juvenile Salmon

The major difference between Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 1—Existing Conditions is that transport of juvenile salmon by truck and barge would be maximized under Alternative 2. Therefore, the impacts on wildlife under Alternative 2 would be expected to be the same as under Alternative 1.

It is not known how many more juvenile salmon would be removed from the river under this alternative. However, in 1996, 98 percent of all fish collected at Lower Granite Dam were transported, leaving approximately 100,000 fish that were bypassed (of the fish collected) (Corps, 1996b). Thus, Alternative 2—Maximum Transport of Juvenile Salmon would be expected to remove about another 100,000 juvenile salmon from the river, particularly since this alternative might be implemented with additional management activities such as altered spill scenarios. This would reduce the number of juvenile salmon available as prey for some bird species such as the double-crested cormorant, white pelican, and Caspian tern. However, these species consume a wide variety of fish species, and their populations would not be expected to decline if fewer juvenile salmon were available.

5.5.2.3 Alternative 3—Major System Improvements

The primary difference between Alternative 3—Major System Improvements and Alternative 1—Existing Conditions is the addition of various fish bypass structures to the existing dam facilities under Alternative 3. The installation of these major system modifications would be expected to result in very few migrating juvenile salmon left in the river between Lower Granite and Ice Harbor (see Section 4.5.1, Anadromous Fish).

Similar to Alternatives 1 and 2, Alternative 3— Major System Improvements would reduce the number of juvenile salmon available as prey for aquatic and avian predators in the three reservoirs below Lower Granite. However, this indirect negative effect would not be expected to significantly impact any wildlife species because they would be expected to substitute other fish as prey.

5.5.2.4 Alternative 4—Dam Breaching

The remainder of this section focuses primarily on the anticipated effects of Alternative 4—Dam Breaching on wildlife resources in the study area. Effects of this alternative on different species groups (e.g., waterfowl, big game, raptors, and furbearers) are addressed separately. Potential effects on threatened and endangered species are addressed last.

Under Alternative 4—Dam Breaching, the existing reservoirs in the study are would be drawn down to pre-dam river levels. This means a drop in elevation of the operating pool from between 94 and 110 feet. The alternative would expose approximately 13,772 acres of previously inundated land. As described in Section 5.5.1, Vegetation, this alternative would be expected to have a negative impact on riparian habitat. Most riparian habitat outside of the irrigated HMUs (which would be maintained under Alternative 4—Dam Breaching) would be expected to desiccate and return to upland habitat within a few years. Also, most of the existing emergent wetland habitat along the current reservoir shoreline would be expected to disappear (Table 5.5-2). This change in habitat would be expected to produce short-term negative effects on wildlife, including direct mortality to wildlife susceptible to desiccation (such as amphibians) and indirect mortality due to loss or change in habitat (otter, riparian-associated bird species). Conversely, some wildlife would be expected to receive short-term benefits from the drawdown alternative, such as shorebirds (who would benefit from thousands of acres of exposed mudflats) and colonial-nesting terns and gulls (who would have more area of exposed islands for nesting). Also, maintenance of the irrigated HMUs combined with an active vegetation management plan (including aggressive native tree and shrub planting combined with control of noxious weeds) would be expected to minimize and mitigate for some of these short-term negative effects and hasten the long-term benefits that would be expected to accrue for many species with the restoration of a more continuous, functioning riparian zone in the study area.

If Alternative 4—Dam Breaching is chosen, a new mitigation plan would likely be developed for the Lower Snake River Project. The old mitigation as described in Technical Appendix L, Lower Snake River Mitigation History and Status would end. The new mitigation would use likely continue use HEP to measure mitigation status along the lower Snake River. The baseline for the new mitigation would be the same as the current mitigation. The 1958 HEP figures would again provide the baseline. The irrigation intakes at existing irrigated HMUs would have to be modified so the vegetation on these sites can be maintained. The additional lands which were purchased and developed would also need to be maintained to provide some interim habitat value until the lower Snake River lands can reestablish riparian vegetation. Technical Appendix L, Lower Snake River Mitigation History and Status shows the potential acreage and HU of habitat lost and the amount of habitat currently being compensated on irrigated sites in the Lower Snake River Project, and the additional lands managed by the WDFW.

Game Birds

As described in Section 4.6-2, Wildlife, the major game bird species in the study area are the ring-necked pheasant, chukar, quail, and mourning dove. Dam breaching under Alternative 4 would initially create a large barren gap in vegetation between the restored

river and current riparian and upland vegetation. This gap would increase the exposure of game birds to predators while foraging, breeding, or seeking water along the edges of this gap. Landscape-level increases in edge habitat have been shown to increase mortality during the spring breeding period of ring-necked pheasants in agricultural landscapes (Schmitz and Clark, 1999). There would be no natural cover for roosting, feeding, escaping or nesting along the approximately 13,772 acres of exposed shorelines, mudflats, and islands for an undetermined amount of time following dam breaching. Although extensive revegetation efforts are planned, natural cover would be expected to be limited for at least 5 to 10 years.

In the short term, activities associated with removal of earthen embankments at each dam and the subsequent construction of diversion dams (such as stockpiling and haul road construction) would be expected to have minor direct negative effects on upland game bird habitat and indirect negative effects on species using that habitat for nesting or cover. It is estimated that approximately 2,000 acres of upland habitat would be negatively impacted by construction activity at all four dams (Technical Appendix D, Natural River Drawdown Engineering). Construction activity includes stockpile areas for imported and exported materials (riprap, fill from earthen dams, levee material), haul roads, equipment storage areas, and staging areas. These areas would be expected to have an average use time of 2 years (dam breaching would occur over a span of 4 years, 2 years at each pair of dams). However, these negative effects would be minimized by locating the staging areas in previously impacted areas outside of irrigated HMUs.

Regardless of the amount of restoration along the old and new shorelines, a significant change in the character of the vegetation along the river would be expected to occur. These changes may include: 1) loss of woody vegetation along the old shoreline due to lack of water (270 acres), 2) increased invasion of exotic species along the exposed ground, 3) loss of vegetation due to sloughing and erosion, and 4) restoration of a more contiguous riparian zone along the new river channel. These changes would undoubtedly have some indirect effects on the ability of game birds in the short term. An increase in exotic species would be expected to benefit game birds.

However, in the long term, it is likely that Alternative 4—Dam Breaching would have significant positive benefits for game birds. The WDG (1984) describes how upland game populations were "severely reduced" due to the loss of riparian habitat, with rough estimates of 120,000 individuals (including pheasant, quail, chukar, gray partridge, mourning dove, and cottontail) being lost. Approximately 12,240 acres of upland habitat would be expected to be restored in the study area in the long term (Table 5.5-2). Thus, where a series of isolated irrigated HMUs exist now to provide habitat, a more continuous band of riparian habitat would be created, with populations likely to increase. Furthermore, the revegetation plan will include approximately 300 additional acres of food plots and approximately 5,000 acres of bunchgrass grassland to meet mitigation goals for upland game birds.

Waterfowl

Alternative 4—Dam Breaching would be expected to have short-term negative effects on waterfowl in the four reservoirs, including elimination of much of their current shallow-water habitat at the edges of the existing reservoirs. In both the short and long term, the

lowering of the reservoirs would likely create land bridges to existing islands, (New York and Silcott Islands). Even islands that are not connected to the new shoreline would likely have increased predation because of the access shallow water would provide for predators such as coyotes, raccoons, and others. Asherin and Claar (1976) found that when a decrease in water level elevation in McNary Reservoir in 1975 exposed land bridges to Badger and Foundation Islands, as well as three of the five Hat Islands, coyotes destroyed all nesting attempts and killed four adult geese on Hat Islands. Under Alternative 4—Dam Breaching, this effect would likely be offset by the exposure of former nesting habitat that was inundated by the reservoirs. Over 50 islands larger than 5 acres in size were inundated behind the Lower Snake River dams (Boe, 1988). These islands supported approximately 100 goose nesting sites on nearly 1,500 acres (WDG, 1984). However, there would likely be a delay in any increased reproduction from the newly exposed islands until appropriate vegetation for nest-building and cover is established.

Similar to its effect on game birds, the exposed drawdown zone would be expected to increase exposure of waterfowl broods to predation as they travel to water. Also, it is likely that while the flush of new growth would be likely to increase short-term forage, the combination of exposed mudflats, heavy weedy growth, and riprap could create barriers to young waterfowl. Furthermore, all current goose nesting boxes would be located farther from water. It is likely that many of these tubs currently being used would be abandoned when the water level dropped significantly. Also, dam breaching would expose shorelines that are likely to experience sloughing and erosion, posing further barriers to waterfowl broods.

Higher water velocities would be expected under a natural river scenario. This would minimize the potential establishment of submerged aquatic plants such as pondweeds and waterweeds which would be eliminated by drawdown. Overall, in the short term, Alternative 4—Dam Breaching would eliminate these potential food sources for waterfowl. In the long term, higher water velocities in the river would interfere with the establishment of submergent aquatic vegetation some areas. However, other shallow-water areas would be exposed and, over an undetermined amount of time, would establish new submergent aquatic vegetation. Waterfowl such as diving ducks, the American coot, and the American widgeon would be most affected by this change.

The waterfowl population of the lower Snake River would be expected to decline in the short term as the result of dam breaching. It is likely, however, that many of these birds would move to nearby slackwater areas such as McNary Reservoir and McNary Wildlife Refuge. This movement would be encouraged by the fact that no hunting is allowed in the McNary Reservoir from the mouth of the Snake River to Ice Harbor Dam. However, many of the shallow-water habitats of the McNary Pool are expected to experience considerable deposition of sediment released by breaching the Snake River dams. Most (over 50 percent) of this deposition would be expected to occur north of Wallula Gap, on the eastern shore of the reservoir (Technical Appendix F, Hydrology/Hydraulics and Sedimentation). It is unknown how or if this deposition will potentially affect waterfowl displaced from the Snake River reservoirs.

Similar to the effects on upland game birds, it is likely that Alternative 4—Dam Breaching may have short-term negative impacts on waterfowl. However, Alternative

4—Dam Breaching would also have significant positive long-term benefits, as all the islands inundated in the past may reemerge unless eroded. These islands may eventually provide more nesting and brooding habitat for Canada geese and other waterfowl, potentially similar to what existed prior to dam construction (Asherin and Claar, 1976). In addition, the large sediment loads currently stored behind the dams could provide source material for new sandbars and shallow areas as the river establishes a new channel. Although wintering waterfowl would experience disturbance during the actual drawdown process, after it is complete, there would potentially be an increase in the amount of shallow water areas available for foraging and resting. With island exposure, no new habitat development would be required. Some island management would be needed to promote a vegetation community that is attractive to waterfowl nesting.

Shorebirds

Alternative 4—Dam Breaching would be expected to have positive short-term indirect effects for shorebirds, as the amount of mudflats (which provide foraging and nesting habitat) would increase significantly in the short term. However, this benefit would decrease as these mudflats revegetated. Under Alternative 4—Dam Breaching, approximately 13,772 acres of mudflats would be exposed. In the short term these exposed areas could provide foraging and nesting habitat for migrating and resident shorebirds (Taylor and Trost, 1992). However, this effect should only last a few seasons until the flush of regrowth from the seed bank and the planned restoration activities have begun. The seed bank along the lower Snake River has been shown to have the potential for rapid recolonization of these exposed areas above 15 feet below the old reservoir level (Robberecht, 1998). Abundance and species richness of migratory shorebirds would likely increase during the first few years following dam breaching, but then their abundance should return to pre-project levels. Nesting habitat for the few breeding shorebird species in the study area (mainly killdeer and spotted sandpiper) should increase in the short and long term as more mudflats would be exposed under natural river conditions under Alternative 4—Dam Breaching.

Colonial-nesting Birds

Colonial-nesting birds are currently uncommon along the lower Snake River, with the exception of cliff and bank swallows (see Section 4.6.2.4). Under Alternative 4—Dam Breaching, drawdown of the reservoirs would increase the amount of exposed areas available as nesting habitat for bank swallows in the short term. Similarly, abandonment of the four dam structures would reduce disturbance thereby improving nesting conditions for cliff swallows that utilize various portions of these structures as nesting habitat.

There are only two large islands in the reservoirs at this time, New York and Silcott, and neither of these islands supports nesting populations of terns or gulls. Some suitable nesting habitat for terns and gulls may be created in the short term by the exposure of additional island habitat along the river. However, this habitat is not likely to remain suitable in the long term due to easy access for predators (due to shorter water crossing distances), the encroachment of woody vegetation such as Russian olive, cottonwood, and black locust as well as native trees and shrubs that will be planted as part of the vegetation management plan. Notably, large nesting colonies of gulls and terns on

islands in the Columbia River (e.g., Rice Island) are suspected of causing significant mortality of salmon smolts through predation (Technical Appendix M, Fish and Wildlife Coordination Act Report). For this reason, reduction in suitable nesting habitat along the river for these bird species is pursuant to the goals of the measures evaluated in this Feasibility Study.

In contrast to habitat for gulls and terns, long-term development of mature riparian habitat along the new river under Alternative 4—Dam Breaching would be expected to improve the suitability of the study area for nesting by heron species. The Corps has no known observations of this species currently nesting along the lower Snake River above Ice Harbor Dam (Corps, 1999b; Rocklage and Ratti, 1998). Finally, Alternative 4—Dam Breaching may provide eventually provide the habitat features (such as increased nesting and roosting structures) necessary to allow double-crested cormorants to nest in the study area, which they did prior to inundation (Weber and Larrison, 1977). Also, more islands would increase the nesting opportunities for the white pelican, a state endangered species currently known to nest only on Crescent Island.

Raptors

The major impact on raptor species from the dam breaching under Alternative 4—Dam Breaching would be indirect effects on prey availability. Anticipated reduction in abundance of waterfowl (as described previously) and small mammals (see Small Mammals section below) in the study area would be expected to have negative effects on the availability of prey for raptors. Also, loss of riparian trees and shrubs would have a direct negative effect on red-tailed hawks by reducing potential nesting habitat. These negative impacts would be expected to be short term while a new riparian zone establishes. Maintaining irrigation in the HMUs would minimize these effects. Reduction of the water level in the reservoirs may increase the availability of cliff nesting for some raptor species. In the long term, development of a mature riparian forest would provide more tree-nesting, roosting, and perching opportunities for some raptor species, particularly owls. Owls and other cavity-nesting raptors would also benefit from the creation of snags along the old shoreline. Also, the long term gain of 12,240 acres of upland habitat will increase the availability of open foraging habitat for species such the American kestrel and northern harrier.

Other Non-game birds

Negative effects to other non-game birds from Alternative 4—Dam Breaching would be due to the short-term elimination of riparian habitat that would result from drawdown. Riparian habitat along the existing shoreline has by far the greatest species richness and bird abundance of habitats along the river with the irrigated HMUs exceeding all other riparian habitats (Asherin and Claar, 1976; Rocklage and Ratti, 1998). Much of the existing riparian habitat would be permanently lost, approximately 1,189 acres, except in the irrigated HMUs (Table 5.5-2). As a result, the populations of some breeding birds could decline in the short term, including northern orioles, song sparrows, willow flycatchers, yellow-breasted chats, and yellow warblers (Rocklage and Ratti, 1998). In the long term, there may be an increase in the quality of riparian habitat (e.g., size of trees, diversity of structure, etc.), but not for 20 to 50 years. Species that may benefit

from the development of a mature riparian forest and thus increased availability of nesting and foraging habitat include the downy woodpecker, yellow warbler, and song sparrow. Other species that would be expected to benefit include lazuli's bunting, black-capped chickadee, northern oriole, and western screech owl. Some of these species may benefit from the presence of cavity-bearing snags before then.

Also, the elimination of most emergent wetlands and marshes along the margins of the current reservoirs would have minor negative impacts on bird species dependent on those habitats for nesting, such as marsh wren and yellow-headed and red-winged blackbird. There are less than 400 acres of emergent wetlands in the study area currently (see Section 4.6.1.2, Riparian and Wetland Habitats). Other bird species that forage in the vicinity of these habitats would also be negatively impacted. To compensate for losses of riparian species, it is estimated that 800 acres of riparian forest (cottonwood), 500 acres of mesic shrubland (hawthorn, hackberry) and 1,500 acres of palustrine scrub-shrub (willow) plantings would have to be established after drawdown.

Big Game

Negative effects on riparian habitat from the dam breaching under Alternative 4—Dam Breaching would be expected to reduce the abundance of mule and white-tailed deer in the canyon in the short term. Riparian habitat outside irrigated HMUs would be expected to deteriorate following drawdown. This would eliminate much of the suitable forage and cover along most of the existing shoreline. In the long term, lowering the reservoirs would likely improve the suitability of the canyon as winter range for deer by increasing the amount of brush and tree vegetation that would provide cover. WDG (1984) estimated that habitat capable of supporting 1,200 deer was lost following inundation of prime wintering habitat along the lower Snake River. Although approximately 1,189 acres of riparian habitat are estimated would be lost in the short term, approximately 1,481 acres would be expected to develop in the long term along the new river channel (Table 5.5-2). Furthermore, the revegetation of the exposed shorelines would be expected to provide new opportunities for forage once suitable habitat has developed. The creation of land bridges under Alternative 4—Dam Breaching would facilitate access by predators to fawns being raised on existing islands; however, currently only New York Island provides potential suitable cover for fawning. In contrast, there would be more newly exposed islands available where deer could seek refuge during fawning once suitable cover has developed.

Alternative 4—Dam Breaching would have little or no effect on other, more rare big game animals along the river such as elk, bighorn sheep, black bear, and mountain lion. These species occur in very low numbers in the canyon or are not associated with the riparian zone (i.e., bighorn sheep). Creating a more contiguous riparian zone would potentially improve the suitability of the study area as a travel corridor for some of these species; however, there is no evidence that these species are more than occasional transients in the study area. No additional habitat developments would be needed for big game.

Small Mammals

In the short term, small mammals would potentially be negatively affected under Alternative 4—Dam Breaching by the elimination of riparian habitat along the existing shoreline and the increased distance to water. Based on the fact that Rocklage and Ratti (1998) found more individuals and species of small mammals in the irrigated HMUs than any other habitat type (including upland or grassland), maintenance of irrigation at these sites would be expected to minimize this negative impact. Another potential negative impact is the potential for increased exposure to predators both along the existing shoreline and for any individuals foraging on sprouting vegetation in the drawdown zone. However, these potential short-term negative effects would be expected to diminish in the long-term as new riparian vegetation develops along the new river channel, providing habitat that may be less fragmented, have a higher percentage of native species (which will be encouraged by active vegetation management by the Corps), and cover more area (1,481 acres gained versus 1,189 lost – Table 5.5-2). Any small mammal species that associated with upland habitats (e.g., grassland, shrub-stepp) such as Ord's kangaroo rat or bushy-tailed woodrat, would be expected to gain significant benefits from drawdown as upland habitat would be expected to increase by approximately 12,000 acres in the study area (Table 5.5-2).

Alternative 4—Dam Breaching would be expected to have some potential negative effects on bats. The reduction in water surface would eliminate some foraging habitat as well as breeding habitat for invertebrate prey species. Many of the embayments and side channel ponds that would be exposed by drawdown are presumed to currently support breeding insect populations. The species most likely to be affected are the Townsend's big-eared bat and the Yuma myotis, since both of these species are associated with water (see Section 4.6.2.9 for more information). Also, the elimination of any riparian vegetation along the existing shoreline would be expected to potentially eliminate some roosting and foraging habitat for bats. However, these potential negative effects may be mitigated by the following potential benefits of drawdown: 1) creation of snags along the existing shoreline that may be used as roosting sites, 2) exposure of cliff habitat that could be used by species such as the western pipistrelle for roosting or hibernacula (approximately 650 acres of rock will be exposed under Alternative 4—Dam Breaching; Table 5.5-2), and 3) the long-term development of riparian vegetation along the new river channel combined with maintenance of the irrigated HMUs.

Furbearers

Under Alternative 4—Dam Breaching, terrestrial furbearers such as coyote, raccoon, and bobcat would be expected to indirectly benefit from anticipated short term increases in the availability of prey as waterfowl, invertebrates, and small mammals become more vulnerable due to the receding water and the lack of cover along the new shoreline. However, loss of riparian habitat in turn would reduce the availability of resting and denning habitat for these species.

Similarly, aquatic furbearers would be expected to have increased availability of prey such as fish and crayfish in the short term. However, in the long term they would likely experience negative effects from the increased distance between water and vegetation, the lack of cover at the water's edge, and the reduction in wetland habitat (loss of

approximately 600 acres; Table 5.5-2). The otter is one of the few species that has actually become more abundant due to the establishment of the reservoirs, which provide substantial denning habitat in the riprap along the shores. The dam breaching under Alternative 4 would isolate these current dens from the new shoreline, creating some negative disturbance effects. Substantial amounts of additional riprap would be placed along the exposed banks (Technical Appendix D, Natural River Drawdown Engineering), but the linear riprap coverage would be reduced from the current length of about 97 miles of shoreline to about 51 miles. Muskrat and beaver would be expected to more negatively impacted than otter. Muskrat are more closely associated with emergent wetland habitat, almost all of which would be eliminated in the short term under Alternative 4—Dam Breaching (Table 5.5-2). The long term effect would depend on how quickly wetland habitat develops along the new river channel. Beaver would lose access to food sources immediately adjacent to the river. They would be able to travel upslope to access stands of shrubs or trees along the old shoreline or in irrigated HMUs, but this would increase their exposure to predation. However, this negative effect on beaver could in turn reduce grazing pressure on any woody stems planted as part of revegetation efforts. In general, however, populations of terrestrial and aquatic furbearers would likely stabilize and recover from the dam breaching in the long term as the riparian zone and aquatic prey base recover. No additional habitat development would be required for river otter and other furbearers.

Amphibians and Reptiles

Alternative 4—Dam Breaching would be expected to have significant direct and indirect negative effects on amphibians in the short term. It is likely that the permanent removal of water and loss of riparian and wetland habitats would eliminate many amphibians through desiccation and exposure to predators. Loper and Lohman (1998) experimentally showed that amphibian eggs exposed to desiccation for little more than a day are no longer viable. Thus, amphibian populations would be expected to be severely impacted in the short term under Alternative 4—Dam Breaching, potentially including the loss of the entire population along some stretches of the river. However, in the long term, the amphibian assemblages along the new river channel may recover to pre-impoundment levels through the creation of more extensive shallow water habitats and more extensive riparian habitat. The establishment of new riparian vegetation may create dispersal corridors for these species as well as provide more extensive areas for egg-laying and escape from predators.

Reptiles are generally more mobile than amphibians and less dependent on aquatic habitat, except for turtles. Therefore, it is unlikely that Alternative 4—Dam Breaching would have any significant indirect or direct effects on reptiles. However, revegetation efforts following dam breaching would hasten the development of habitat suitable for cover for both amphibians and reptiles. In particular, some special consideration may need to be given to the isolated western painted turtle population at the Chief Timothy HMU. The pond that supports this small population may dry up under the drawdown scenario, which would eliminate habitat for this population.

5.5.3 Species with Federal Status

5.5.3.1 Plant Species

This section discusses the potential effects of the alternatives on five plant species with Federal status under the Endangered Species Act (ESA) that may occur in the study area. These plants are water howellia, McFarlane's four-o'clock, Ute ladies'-tresses, Howell's spectacular thelypodium, and basalt daisy. Potential effects to plant species of concern are not addressed separately within this section but instead are addressed by the overall effects on vegetation communities in Section 5.5.1, Vegetation. Potential effects of the proposed project on Federally listed species are described in more detail in a separate biological assessment, as required by Section 7 of the ESA, that is being prepared concurrently.

Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, and Alternative 3—Major System Improvements

As discussed earlier in this section, no significant changes would occur to existing vegetation associated with project activities, therefore, no impacts are anticipated to occur to potentially occurring threatened or endangered plant species or their habitat types.

Alternative 4—Dam Breaching

Water Howellia

Under Alternative 4—Dam Breaching, potentially suitable habitat for water howellia (seasonal wet areas) would be expected to be lost in the short and long term. Approximately 669 acres of wetlands are expected to be lost under Alternative 4—Dam Breaching (Table 5.5-2). However, the nearest population is approximately 60 miles north of the study area, in Spokane County, Washington. Thus, the likelihood of negative effects to populations of this Federally threatened species is low. The new river channel may provide more potentially suitable habitat for this species than the current shoreline due to naturally fluctuating water levels. However, this would depend on future biological, physical, and hydrologic conditions, and on land management decisions.

Ute Ladies'-tresses

This Federally threatened species is associated with wetland and riparian areas. Alternative 4—Dam Breaching would be expected to eliminate some potentially suitable habitat for this species in the study area in the short and long term. However, the nearest populations are in southeastern Idaho and northern Washington. Thus, the likelihood of this species occurring in the study area is low. Similar to water howellia, Ute ladies'-tresses may benefit from the potential long term development of wet areas beside the new river channel. However, this would depend on future biological, physical, and hydrologic conditions, and on land management decisions.

McFarlane's Four-O' Clock

No effects are anticipated to occur to this species since it is not expected to occur within the study area, and is associated with upland habitats, most of which are unaffected by project activities. The nearest population is in Hells Canyon, Idaho. Effects to potential populations of this species under this alternative could include habitat destruction related to ground-disturbing activities associated with dam decommissioning. Construction of haul roads and stockpiling could impact unrecorded populations or potential habitat for the species. Upland habitat elsewhere within the project boundary should improve as grazing restrictions are maintained.

Howell's Spectacular Thelypodium

This plant species is proposed for Federal listing. Suitable habitat for this species is very limited in the study area (wet alkaline meadows in valley bottoms). Also, the nearest population is approximately 100 miles away near Haines, Oregon. Alternative 4—Dam Breaching would be expected to have no effect on this species because of the low probability of occurrence in the study area.

Basalt Daisy

This plant species is a candidate for Federal listing. Suitable habitat for this species (basalt rock faces) does occur in the project area. The nearest population is approximately 90 miles from the study area. Alternative 4—Dam Breaching would be expected to have no negative effects on this species, but potentially suitable habitat would be exposed after drawdown. Approximately 660 acres of rock will be gained with drawdown (Table 5.5-2).

5.5.3.2 Wildlife Species

Only one Federally listed wildlife species is known to occur in the study area–the bald eagle. Four additional federally listed species, the gray wolf, Oregon spotted frog, Canada lynx and the grizzly bear, are not known to occur but could potentially occur as transients.

Bald Eagle

In the short term, Alternative 4—Dam Breaching would be expected to indirectly benefit wintering bald eagles by increasing the availability of stranded salmon and other fish prey as water levels recede. In the intervening years as the natural vegetation recovers, some potential eagle perching trees could die from lack of water. However, in the very long term (greater than 50 years), large trees would be expected to develop along the restored river channel, which would be expected to substantially improve habitat suitability for eagles along the lower Snake River.

Gray Wolf

As described in Section 4.6.3.2, it is possible that members of the reintroduced, experimental population of gray wolves living in central Idaho could disperse into the study area. However, this is highly unlikely given the current levels of human activity

and the relatively high road density. Thus, Alternative 4—Dam Breaching would be expected to have no impact on gray wolves.

Grizzly Bear

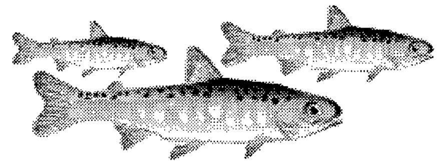
Alternative 4—Dam Breaching would be expected to have no significant direct effect on grizzly bears, which do not occur near the study area. If dam breaching results in a sustained long-term increase in native salmon runs in upstream tributaries of the Snake River (e.g., Clearwater River), it could indirectly benefit any experimental population of grizzlies that may be established in central Idaho.

Oregon Spotted Frog

Alternative 4—Dam Breaching would be expected to have no direct effects on the Oregon spotted frog since the nearest known population is in Klickitat County, Oregon. Approximately 660 acres of potentially suitable habitat (wetlands) would be lost in the long term under Alternative 4—Dam Breaching (Table 5.5-2).

Canada Lynx

Alternative 4—Dam Breaching would be expected to have no direct effects on Canada lynx, because there is no suitable habitat in the study area and there are no known observations of this species in the study area.



5.6 Cultural Resources

This section discusses the potential impacts on historic and cultural properties associated with the four alternatives. Short-term effects are associated with demolition-related activities, and shoreline fluctuations that would occur with a return to approximate natural river levels. Long-term effects are effects that persist after geomorphic systems have stabilized (e.g., revegetation of exposed sediments, shoreline stabilization). This section also discusses mitigation measures to address impacts to sites resulting from dam breaching. The information provided in this section is primarily derived from Technical Appendix N, Cultural Resources, and Appendix D of the System Operation Review Final EIS (BPA et al., 1995). See Table 5.6-1 for a summary of potential effects.

5.6.1 Cultural Resources Impact Issues

Changing water levels and flows can cause wave action, inundation, and exposure of reservoir drawdown zones, all of which can affect cultural resources. System operations can also have impacts on historic properties as a result of changes in the human use and aesthetics of the shore and drawdown zones. Impacts to archaeological deposits occur differently in each of the four reservoir zones: The littoral zone (exposed beach), wave-action zone, inundation zone, and shore zone (Figure 5.6-1).

Table 5.6-1. Summary of Potential Effects of the Alternatives on Cultural Resources

Alternative 1	Alternative 2	Alternative 3	Alternative 4
No change from current conditions.	Slight increase in wave action impacts from additional barge traffic; otherwise same as Alternative 1.	Slight increase in wave action during installation of new systems, but this would be temporary; otherwise same as Alternative 1.	• Increased rate of site exposure and associated hazards. • Corresponding access for scientific research and cultural resources management. • Creation of conditions that would allow the theft of cultural or historic properties, damage and destruction of valuable cultural resources, and associated law enforcement problems. • Extensive costs incurred for cultural resource evaluations. • Renewed access to traditional cultural practices and traditional fishing areas by Tribes.

Exposed archaeological deposits within the littoral zone are subject to impacts that are mechanical, human, and animal in origin. Erosion is the primary concern for cultural resources in this zone and in the wave-action zone. Generally, soils on which the lower Snake River hydropower facilities are located are derived from glacier and flood deposits. They are light soils, highly susceptible to erosion by water and wind. In addition, the lower Snake River reservoirs have steep slopes that are somewhat susceptible to slumping and landslides.

Because inundation removes vegetation, wind and water (runoff) erosion deflates archaeological sites in the littoral zone. Deflation is the removal of the archaeological soils, leaving heavier items and artifacts in place. Water running over unvegetated slopes also causes erosional rills and gullies and moves artifacts. The movement of artifacts and site features within or away from a site decreases its scientific integrity and value because it becomes more difficult to reconstruct the site's original features and placement of artifacts. The littoral zone is also subject to repeated cycles of wetting and drying, which can cause organic deposits, such as bone, and some artifacts, such as ceramics, to deteriorate. Erosion from livestock trampling and wallowing is also a concern in this zone.

In the wave-action zone, wind- and powerboat-generated wave action erodes and deflates archaeological sites. It may also stimulate geomorphological changes that can destroy intact archaeological deposits. These changes can include slumping,

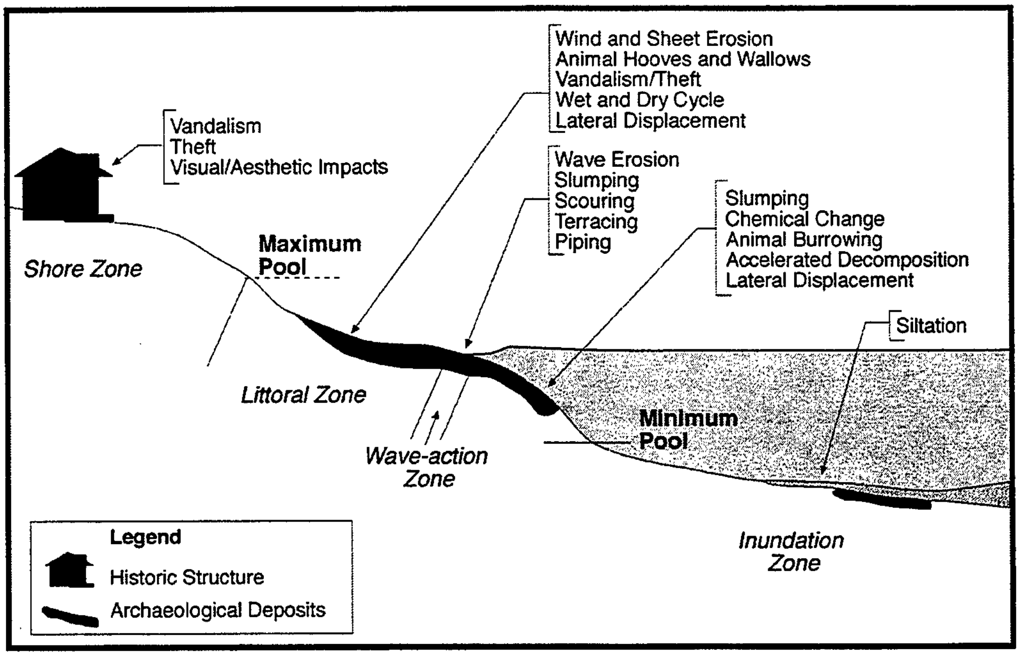


Figure 5.6-1. Reservoir Impact Zones and Potential Impacts on Historic and Cultural Properties

scouring, terracing, and piping (see Section 10, Glossary, for definitions of these terms).

Impacts on archaeological deposits in the inundation zone include sedimentation, erosion, chemical change, and accelerated decomposition. In general, sedimentation in the project reservoirs tends to enhance cultural resource preservation by providing a sediment buffer against mechanical impacts (e.g., wave action). However, cultural resources buried under a deep silt and water column are no longer accessible for research, and little is known about the long-term impacts of deep sediment burial on fragile cultural deposits. There have been no definitive studies of the impacts of heavy silt deposit on cultural resources; but it is prudent to assume that soil saturation, soil movement, and other processes may result in some adverse impacts to cultural resources. Underwater landslides and sediment shifts are known to occur in the permanently inundated zones of reservoirs (Ware, 1989).

Cultural resources in the inundation zone that are not completely covered with silt are subject to underwater currents that displace materials and artifacts. Archaeological deposits can also be disturbed and moved by aquatic organisms such as burrowing clams. Reservoir water can degrade cultural resources. It dissolves organic materials and ceramics, and changes chemical attributes, such as pH, phosphate, and nitrogen levels of deposits. An accumulation of organic acids accelerates the decomposition of organic materials and ceramics.

Impacts to historic and cultural properties due to system operating strategies also result from human use of the shore and littoral zones. For example, reservoir operations affect the attractiveness of the reservoir for recreation, and thereby influence the number of people visiting these zones. The devegetation and deflation

of archaeological sites in the littoral zone, furthermore, make them more visible to the public. When more people are present and archaeological sites are more visible, there is a greater likelihood of vandalism and artifact theft.

Land management actions not related to system operations can also affect human activities at the reservoirs, and different uses can have different effects on archaeological and historic sites near project reservoirs. Decisions to develop or permit camping or hiking trails, for example, may lead to increased impacts on historic and archaeological sites from human-caused erosion, vandalism, and artifact theft.

Project operations that change land uses might also change the integrity of "feeling" or association of a historic or cultural property. For example, change in nearby recreational uses might adversely affect a traditional cultural property such as a Native American ritual site, by increasing sights and sounds incompatible with ritual use. Reservoir drawdown might destroy the visual integrity of a historic site or traditional cultural property by introducing an element that is inconsistent with its historic or cultural character.

5.6.2 The Alternatives and Their Impacts

5.6.2.1 Alternative 1—Existing Conditions

Under Alternative 1—Existing Conditions, for concerns pertaining to cultural resources, the four hydropower facilities on the lower Snake River would continue to operate as originally designed. For the most part, geomorphic processes have reached a near-equilibrium under operations since the impoundment of the reservoirs. Ongoing erosion has stabilized to some extent on the reservoirs. Some of this effect is due to bank stabilization structures that have been placed at various locations to slow or halt erosion. Stable systems would not be altered under this alternative. Therefore, the positive and negative impacts associated with this alternative are considered long term.

Within the inundation zone, cultural resources are considered protected, but not preserved. The dominant effects on cultural resources are from inundation and the biochemical processes active in that environment. Sedimentation and underwater erosion processes are active, but secondary factors. The greatest adverse impact on cultural values has been inaccessibility due to inundation and permanent burial in sediment.

Within the reservoir fluctuation area (the area between the minimum and maximum pool levels which includes the littoral, wave-action, and inundation zones), the predominant impact is erosion resulting from wind, ice, waves, currents, and water level changes. Wave action poses the most serious threat in this area. The erosional processes that predominate in the reservoir fluctuation area include mass wasting, sheetwash, channeled flow, wave wash, ice gouging, and deflation. Depositional processes active in this area include mass wasting (mostly in the form of bank caving and sloughing), fluvial deposition from tributary streams, and, when the pool is elevated, sediment deposition from the reservoir. Air-borne deposition is also an important sedimentary process in areas of reservoir fluctuation.

The area of fluctuation is also subject to biochemical and human-caused impact. These impacts are greater in this area than in any other reservoir area. Biochemical activity is accelerated in the shallow waters of the reservoir because of higher light, dissolved oxygen levels, and ambient temperatures. These conditions will support more organisms that may degrade perishable cultural materials. Similarly, the potential for human and animal impacts is greater in the reservoir fluctuation area than in any other reservoir area. Reservoir environment recreation and all its attendant impacts are concentrated at the reservoir shoreline: boat launch ramps, swimming beaches, campgrounds, power boats, and their destructive wakes are all potential sources of adverse impacts to fragile cultural resources.

The shore zone lies above the normal high water line. It is primarily affected by susceptibility of the soils to erosion and mechanical impacts stemming from human use of the land. Although this zone is seldom or never in direct contact with the reservoir pool, reservoir levels directly influence such things as human access to the zone, stability of backshore soils, groundwater fluctuations, and biological composition. Sediment issuing from this zone makes a major contribution to the total sediment load entering the reservoir. Erosion is the primary geomorphic process acting in the shore zone. Potential adverse effects are mostly from mass wasting, sheetwash, channeled flow, and direct rainfall impact. Human use and visitation of the lakeshore increases the possibility of vandalism and theft.

Unavoidable adverse impacts under this alternative relate to the continued inundation of numerous cultural resource sites. Sites within the inundation zone would continue to be affected by sedimentation and underwater erosion processes. Sites located in the reservoir fluctuation area would continue to be subject to fluvial erosion and deposition processes. Human use and visitation to the lakeshore would remain unchanged.

5.6.2.2 Alternative 2—Maximum Transport of Juvenile Salmon

Under this alternative, existing juvenile fishway systems would be operated to maximize fish transport. This would result in an increased number of fish being transported downstream by trucks or barges. Wave action impacts would be slightly increased due to additional barge trips up and down the river. Otherwise, impacts to cultural resources under this alternative would be identical to those described for Alternative 1—Existing Conditions.

5.6.2.3 Alternative 3—Major System Improvements

Structural enhancements to improve downstream migration of juvenile salmon would be added to each of the four lower Snake River dams under this alternative. The proposed enhancements consist of various surface bypass collector (SBC) systems (see Section 3.0, Plan Formulation). Installment of these enhancements could slightly increase wave action in the reservoirs temporarily. Otherwise, impacts to cultural resources under this alternative would be identical to those described for Alternative 1—Existing Conditions.

5.6.2.4 Alternative 4—Dam Breaching

Under Alternative 4—Dam Breaching, reservoirs behind the four lower Snake River dams would be permanently lowered by removing the earth-filled section of each dam to create a 140-mile free-flowing river. This would expose archaeological sites that have been inundated for decades. This alternative would have both short-term and long-term effects on cultural resources.

Alternative 4—Dam Breaching would cause a higher rate of site exposure than the other alternatives. The current set of cultural resource management issues for the four lower Snake River dams in large part would be exchanged for another set. Potential long-term effects on newly exposed sites in this reservoir system would include: vandalism, theft, surface erosion, slumping along river banks and hill slopes, lateral displacement, trampling/wallowing by hoofed animals, rodent burrowing, climatic/precipitation cycles, and biochemical soil changes. It is expected that water flow events such as caused by spring upland releases would have no greater effects than current reservoir fluctuation impacts. Effects would be re-focused to the meandering zone of the natural river course, typically along the river edge.

Under this alternative, short- and long-term river behaviors would re-expose sites to periodic flood events, and river movements that alter terrace structures and river bed channel locations. Such river movements would occur within the limits of the lower Snake River's natural meander zones, which generally are expected to be at lower elevations than the current reservoirs' fluctuation zone. Some sites and portions of sites would be re-exposed with an overlying sediment load of variable thickness due to a 20-plus year period of reservoir inundation conditions. Consequently, sites in these circumstances would remain partially or prohibitively inaccessible.

Many of this alternative's most significant impacts to cultural resources would be short term. Although most known archaeological sites would be exposed in a non-vegetated zone following the reservoir drawdowns, in time, the reservoir landscape would be re-vegetated and other site protective measures established. Benefits to most reservoir resources would include their renewed access for scientific research, direct cultural resource management (e.g., site evaluations, National Register of Historic Places [NRHP] nominations), and traditional cultural practices.

Assuming that the culmination of effects for inundated cultural resources and shoreline erosion to sites is often worse than site exposure, it can be said that alternatives that increase site exposure are possibly best for the resource. Drawdown would remove the previously constant effects of shoreline erosion at the four reservoirs in exchange for free-flowing river behaviors within the river's meander/flood zones. The net long-term effect on cultural and historic properties could be positive. However, a cultural resource management plan (CRMP) with aggressive resource treatments and preservation strategies would need to be funded and implemented.

5.6.3 Cultural Resources Management

Cultural resources management would continue largely as it currently exists for all project alternatives except for Alternative 4—Dam Breaching. Under this alternative,

cultural resources management responses would address newly exposed lands and resources as a special circumstance with many unknowns as to site locations, conditions, and preservation needs. A comprehensive resources inventory to identify and assess resource conditions would be necessary to manage the lower Snake River. Given the uncertainties surrounding cultural resources issues under Alternative 4—Dam Breaching, the extent of possible unavoidable adverse impacts is unknown at this time.

Under a comprehensive resource management strategy, the Corps would gather as much information as possible about the nature and condition of the cultural and historic properties located on its lands. To that goal, the Walla Walla District formed the *Payos Kuus T'suukwe'* working group of the Federal Columbia River Power System Cooperating Group to assist in meeting the Federal responsibility for cultural resource protection and management.

The Cultural Resources Protection Plan

The Federal responsibility to protect and preserve cultural properties under Alternative 4—Dam Breaching could be met by developing and carrying out an effective management plan. The usual subjects of cultural resources management are NRHP-eligible sites threatened by adverse impacts such as construction, inundation, erosion, or vandalism. The majority of inventoried cultural sites in the reservoirs of the lower Snake River dams have not been evaluated (through Determinations of Eligibility for the NRHP). Mitigation or treatment planning hinges on this site evaluation process. Actual treatment of identified sites may vary. The cultural, historic, and scientific importance of cultural sites can be preserved by various physical means. The engineering aspects of the physical CRMP are discussed in Annex N of Technical Appendix D, Natural River Drawdown Engineering). Measures other than site armoring are discussed below. Strategies for individual site protection could include one or many protective measures.

5.6.4 Avoidance or Protection

Identified sites would be surveyed and evaluated. This would be followed by consultation concerning mitigative and protection measures. Some measure of protection can be secured by measures including bank stabilization programs, protective levees, covering sites, and erecting barriers. In some cases, sites can be protected by stabilization efforts such as site capping, slumpage control, and streambank stabilization. Site protection also includes signage, public education programs, and law enforcement efforts.

5.6.5 Data Recovery and Curation

Data recovery and curation involve scientific excavation. Recovered materials and the associated documentation are curated in a facility that meets strict Federal guidelines.

5.6.6 Consultation with Indian Tribes

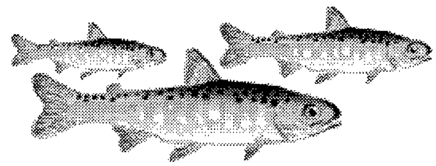
Cultural resources mitigation or treatment efforts undertaken by the Corps require consultation with affected Indian tribes (see Technical Appendix T, Tribal Consultation/ Coordination, for more information). Discussions will include resource management plans.

5.6.7 Coordination with Mitigation Efforts for Other Resources

If overlap occurs with mitigation plans for other resources, planners need to coordinate mitigation efforts so that actions benefiting one resource do not harm another.

5.6.8 Cultural Resources Monitoring

Site monitoring describes observations of site conditions and documents impacts or changes to cultural resources sites over time that can assist in the development of appropriate protection measures. Monitoring plans are developed in cooperation with regional Indian tribes and various interested parties.



5.7 Native American Indians

This section pulls information from a number of sources. One specific source of tribal information is the Tribal Circumstances prepared for this FR/EIS by a private consultant in association with the Columbia River Intertribal Fish Commission (CRITFC) (Meyer Resources, 1999). The Tribal Circumstances and Perspectives report focuses on input from specific tribes and sets forth their perspective. The specific tribes which participated are the Nez Perce Tribe (Nez Perce), the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), the Yakama Nation (Yakama), the Confederated Tribes of the Warm Springs of Oregon (Warm Springs) and the Shoshone-Bannock Tribes (Shoshone-Bannocks).

The Tribal Circumstances and Perspectives report assesses impacts to tribal circumstances in terms of: 1) tribal ceremonial, subsistence, and commercial harvests of salmon and steelhead; and 2) tribal access to flooded lands valuable to tribes. The analysis of salmon recovery and harvest levels presented in the Tribal Circumstances and Perspectives report is based on preliminary numbers. See the Tribal Circumstances and Perspectives report for tribal views with regard to beneficial effects to salmon, estimated time of removal of salmon from the Endangered Species List, etc.

5.7.1 Tribal Harvests

The Plan for Analyzing and Testing Hypotheses (PATH) measured the effect of the proposed alternatives on seven index salmon stocks. The discussion of alternatives presented below is based on preliminary PATH data weighted by PATH's panel of

independent experts and extended by the Drawdown Regional Economic Workgroup (DREW) Anadromous Fish Workgroup to represent all Snake River wild and hatchery stocks. The Tribal Circumstances and Perspectives report presents tribal harvest recovery rates based on this preliminary PATH data and converts these rates into pounds, assuming average weights of 20.1 pounds per salmon for spring and summer chinook, 19.1 pounds per salmon for fall Chinook, and 8.5 pounds per fish for steelhead. Results are discussed below for the 30-year and 50-year benchmarks. Due to concerns associated with the weighting process, unweighted PATH results were used in all other analyses for this feasibility study.

Tribal harvest data are presented for wild salmon and steelhead only in Table 5.7-1. Data are presented for both wild and hatchery salmon and steelhead in Table 5.7-2. The Tribal Circumstances and Perspectives report suggests that these forecasts may be overestimates because the PATH analysis is built from present-day conditions and fails to incorporate long-term negative trends in Columbia River/Snake River stock sizes. The report also suggests that the year 0 assumptions, which were developed by the DREW Anadromous Fish Workgroup (see Technical Appendix I, Economics), likely exceed PATH's present conditions by approximately 34 percent for spring/summer chinook and 43 percent for fall chinook (Meyer Resources, 1999).

Table 5.7-1. Estimated Tribal Harvest of Wild Snake River Stocks in Pounds by Species

Alternative/ Project Year1/	Spring/Summer Chinook ('000 lbs)	Fall Chinook ('000 lbs)	Summer Steelhead ('000 lbs)	Total ('000 lbs)	Total Change from Year 0 ('000 lbs)	Total Change from Year 0 (%)
Alternative 1-Existing Conditions						
0	10.7	8.9	13	32.6		
10	28.2	16.8	19	64	31.4	96.3
30	54.7	21.9	93.6	170.2	137.6	422.1
50	62.4	21.5	94.8	178.7	146.1	448.2
Alternative 2-Maximum Transport of Juvenile Salmon						
0	10.7	8.9	13	32.6		
10	26.8	16.8	18.4	62	29.4	90.2
30	46.1	21.9	90.7	158.7	126.1	386.8
50	48.2	21.5	91.1	160.8	128.2	393.3
Alternative 4-Dam Breaching						
0	10.7	8.9	13	32.6		
10	27.2	24.6	18.9	70.7	38.1	116.9
30	149.3	133.1	113.1	395.5	362.9	1,113.2
50	174.6	133.6	117.6	425.8	393.2	1,206.1

1/ The Tribal Circumstances and Perspectives report does not address Alternative 3—Major System Improvements, but the impacts of this alternative on tribal harvest are likely to be similar to those projected for Alternative 2—Maximum Transport of Juvenile Salmon.

Source: Meyer Resources, 1999 (Table 50)

Table 5.7-2. Estimated Tribal Harvest of Wild and Hatchery Snake River Stocks in Pounds by Species

Alternative/ Project Year[1/]	Spring/Summer Chinook ('000 lbs)	Fall Chinook ('000 lbs)	Summer Steelhead ('000 lbs)	Total ('000 lbs)	Total Change from Year 0 ('000 lbs)	Total Change from Year 0 (%)
Alternative 1–Existing Conditions						
0	20.6	36.2	255.7	312.5		
10	36.7	41.2	272.3	350.2	37.7	12.1
30	97.0	58.2	639.1	794.3	481.8	154.2
50	110.8	65.1	660.6	836.5	524.0	167.7
Alternative 2-Maximum Transport of Juvenile Salmon						
0	20.6	36.2	255.7	312.5		
10	35.3	41.2	269.9	346.4	33.9	10.8
30	82.4	58.2	606.2	746.8	434.3	139.0
50	86.4	65.1	618.3	769.8	457.3	146.3
Alternative 4-Dam Breaching						
0	20.6	36.2	255.7	312.5		
10	43.1	87.9	356.3	487.3	174.8	55.9
30	304.2	650.7	951.5	1906.4	1593.9	510.0
50	355.0	668	990.4	2013.4	1700.9	544.3

1/ The Tribal Circumstances and Perspectives report does not address Alternative 3—Major System Improvements but the impacts of this alternative on tribal harvest are likely to be similar to those projected for Alternative 2—Maximum Transport of Juvenile Salmon.
Source: Meyer Resources, 1999 (Table 50)

The following sections assess the effects of the proposed alternatives in terms of the change from the year 0 estimates. In addition, following the Tribal Circumstances and Perspectives report, comparison is made for Alternative 4—Dam Breaching with current study tribe harvests from all Columbia-Snake River System steelhead stocks. The Tribal Circumstances and Perspectives report estimates that current study tribe harvest from all Columbia-Snake River System steelhead stocks is about 1,338,000 pounds.

5.7.1.1 Alternative 1—Existing Conditions

Alternative 1—Existing Conditions would maintain existing conditions with scheduled improvements. Data presented in Tables 5.7-1 and 5.7-2 indicate that the tribes would harvest 32,600 pounds of wild Snake River salmon and steelhead and 312,500 pounds of wild and hatchery Snake River salmon and steelhead at project year 0. Under Alternative 1—Existing Conditions, tribal harvest of wild salmon and steelhead would increase more than four times by the 30-year benchmark. The combined wild and hatchery tribal harvest would increase by about 1.5 times over this period. As noted above, the Tribal Circumstances and Perspectives report asserts that these estimates based on PATH preliminary estimates extended by the DREW Anadromous Fish Workgroup are too high. These numbers do, however, allow some

comparison to be made between alternatives. The Tribal Circumstances and Perspectives report asserts that this alternative offers limited hope of salmon recovery within a reasonable timeframe.

5.7.1.2 Alternative 2—Maximum Transport of Juvenile Salmon

Alternative 2—Maximum Transport of Juvenile Salmon would produce lower stock levels than Alternative 1—Existing Conditions. Tribal wild salmon harvests would increase by about 387 percent over estimated year 0 totals by the 30-year banchmark, while the combined tribal wild and hatchery harvest would increase by about 1.4 times. According to the Tribal Circumstances and Perspectives report, tribal harvest of wild Snake River stocks under this alternative would be about 7 percent lower than under Alternative 1—Existing Conditions. Tribal harvest of wild and hatchery stocks taken together would be about 6 percent less than under Alternative 1—Existing Conditions. The Tribal Circumstances and Perspectives report asserts that this alternative would be unlikely to meet tribal salmon recovery objectives within a reasonable timeframe.

5.7.1.3 Alternative 3—Major System Improvements

The Tribal Circumstances and Perspectives report does not address Alternative 3—Major System Improvements, but the impacts of this alternative on tribal harvest are likely to be similar to those projected for Alternative 2—Maximum Transport of Juvenile Salmon.

5.7.1.4 Alternative 4—Dam Breaching

Tribal harvest of wild salmon would increase by more than 11 times over estimated year 0 totals by the 30-year benchmark and 12 times by the 50-year benchmark under this alternative. Combined wild and hatchery salmon harvests would be about 5.1 and 5.4 times higher than current harvest levels at the 30- and 50-year benchmarks, respectively. By year 50, estimated tribal wild and hatchery harvest would increase by about 1.7 million pounds—increasing current study tribe harvests from all Columbia-Snake River System steelhead stocks by 2.3 times. This alternative would produce 2.4 times more tribal harvest of Snake River wild salmon and steelhead stocks than Alternative 1 (2.6 times more harvest than Alternative 2). The Tribal Circumstances and Perspectives report concludes that only this alternative would redirect river actions toward significant improvement of the cultural and material circumstances of the five study tribes.

5.7.2 Tribal Land Use

5.7.2.1 Alternative 1—Existing Conditions

Alternative 1—Existing Conditions would continue the current land management practices and would not impact the current land use of the tribes.

5.7.2.2 Alternative 2—Maximum Transport of Juvenile Salmon

Alternative 2—Maximum Transport of Juvenile Salmon would continue current land management practices and would not impact current tribal land.

5.7.2.3 Alternative 3—Major System Improvements

Alternative 3—Major System Improvements would continue current land management practices and would not impact current tribal land use.

5.7.2.4 Alternative 4—Dam Breaching

Under Alternative 4—Dam Breaching, approximately 14,000 acres of previously inundated land would be exposed. The Tribal Circumstances and Perspectives report indicates that much of this land was used by the tribes prior to construction of the lower Snake River dams for fishing, hunting, and harvesting of roots, plants, and berries. Sites along the river were also used for religious and cultural ceremonies, and burial grounds. The Tribal Circumstances and Perspectives report states that the tribes could benefit greatly from implementation of this alternative if they gained access to, or ownership of, lands that were once used for cultural, material, and spiritual purposes.

After dam breaching, project lands would no longer be used for commercial navigation or hydropower, but a significant portion would likely be needed to meet other existing or newly authorized uses. Significant acreage is, for example, leased to state and local governments and private entities for recreation or fish and wildlife management. It is expected that many of these lessees would choose to continue their operations under a dam breaching scenario. It is also anticipated that continued cohesive management of a significant portion of public lands would be necessary to protect the environmental benefits to salmon associated with dam breaching. Restoration of previously submerged lands is also likely. It would be expected that new authorizing legislation would include provisions to meet restoration objectives. If any lands were no longer required, they could be reported to the General Services Administration (GSA) for disposal. GSA would then screen the lands with other Federal agencies to determine whether there is another Federal requirement for the property. If not, GSA would then dispose of the lands to other eligible public or private entities or individuals.

5.7.3 Summary

According to the Tribal Circumstances and Perspectives report, selection of Alternatives 1 through 3 would, from a cumulative effects perspective, continue to contribute to existing detrimental tribal contributions. Reservoir lands would continue to be inundated and, according to the Tribal Circumstances and Perspectives report, these alternatives do not offer reasonable prospects of a restored tribal salmon fishery for 50 years or more. A strategy that commits to "further study" is seen by the tribes as a delay in enacting more substantial recovery measures and would, therefore, also commit to continuing current tribal suffering.

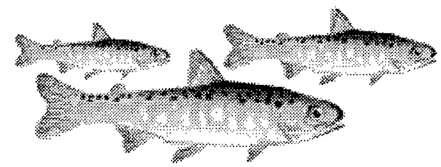
The Tribal Circumstances and Perspectives report states that selection of Alternative 4—Dam Breaching would have the opposite effect on cumulative trends. It offers the

highest rates of recovery for wild salmon and steelhead and would also expose approximately 14,000 acres of currently inundated lands.

These lands were used prior to settlement by non-Indians in the mid to late 19th century, and are still valued, by the tribes for cultural, material, and spiritual purposes. Under the other three alternatives, these lands would remain inundated by the four reservoirs and inaccessible by tribes. Numerous sites of cultural, material, and spiritual importance to the tribes, including burial grounds, would remain inaccessible. In the Tribal Circumstances and Perspectives report, tribes are requesting remedial actions that are beyond the scope and the timeframe of this FR/EIS. Although the tribes would benefit if reservoir lands were transferred to them, as discussed above, there are no plans at this time to transfer these lands to any entity. The area would need to be revegetated, monitored for cultural resources, and critical habitat would need to be protected for an undetermined length of time.

According to the Tribal Circumstances and Perspectives report, removal of the four lower Snake River dams could have positive long-term impacts on many aspects of tribal life, including the distribution of wealth, health, material well-being, spiritual and religious well-being, and tribal empowerment. The salmon is a defining element of tribal religious and cultural practices. The five study tribes believe that its recovery would generate wealth in these areas, and in tribal economies benefiting from increased harvests. Improved economies would help reverse current adverse health and nutrition circumstances. Access to highly valued, presently inundated, lands would increase opportunities for tribes to partake in religious, cultural, and economic practices. Finally, the Tribal Circumstances and Perspectives report asserts that salmon recovery resulting from Alternative 4—Dam Breaching would increase feelings of empowerment and self-worth among tribal peoples.

The potential effects of the proposed alternatives on low-income and minority groups, including Native Americans, are addressed in Sections 4.14 and 5.13, Social Resources.



5.8 Transportation

The following subsections discuss the effects of Alternative 4—Dam Breaching on navigation, railroads, and highways. Existing navigation facilities would continue to operate under Alternative 1—Existing Conditions through Alternative 3—Major System Improvements. These alternatives are, as a result, represented as the base case condition in the following discussion. Navigation on the lower Snake River would no longer be possible under Alternative 4—Dam Breaching. Table 5.8-1 presents a summary of the potential effects of the alternatives on transportation.

5.8.1 Navigation

5.8.1.1 Methodology

Alternative 4—Dam Breaching would have significant effects upon navigation because barges would no longer be able to operate. Commodities currently transported by barge on the lower Snake River would need to be shipped by rail or truck. The Drawdown Regional Economic Workgroup (DREW) Transportation Workgroup conducted a transportation analysis as part of this Feasibility Study to identify and quantify the direct economic effects resulting from disruption of the existing transportation system. This analysis was designed to measure the effect that breaching the four lower Snake River dams would have on the costs of transporting products that are currently shipped on the Columbia-Snake Inland Waterway. The indirect or secondary changes that would occur at the local and regional level as a result of these changes are discussed in Section 5.13, Social Resources, and more fully in Technical Appendix I, Economics.

Table 5.8-1. Summary of Potential Effects of the Alternatives on Transportation

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Navigation	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• Barges would no longer be able to operate. • An estimated 126.6 million bushels of grain would need to be transported via rail or truck. • The estimated associated cost increase to transport grain would average 27 cents per bushel. • The projected cost increases for other commodities are from 4.8 to 5.8 percent across selected years.
Railroads	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• An estimated 29 percent of the total diverted grain could shift from river to rail for transport. • Investment in railroad infrastructure would be necessary.
Highways	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• An estimated 71 percent of the total diverted grain could shift from river to roads for transport. • Investment in highway infrastructure would be necessary. • Increased traffic congestion and associated safety hazards could occur on affected routes.

The volumes of commodities that would be transported on the lower Snake River under base-case conditions were projected using existing commodity forecasts, historical data, and anticipated supply and demand trends. Projections were made for a 20-year period—2002 to 2022—in 5-year increments for each commodity group (Table 5.8-2).

Total traffic passing through Ice Harbor lock is projected to grow from 3.6 million tons in 1996 to 4.6 million tons by 2002, equaling the peak years of 1988 and 1995 (see Table 4.9-5). Traffic is projected to level off between 2007 and 2012 at just over 4.8 million tons. Growth is then projected to resume at a modest rate through 2017 and 2022, reaching just over 5.2 million tons in 2022. These figures represent the medium or most likely projected values. Low and high scenarios were also projected for each year. Based on these projections, traffic in 2022 could range from a low of 3.4 to a high of 7.1 million tons, but these are projected to be the extreme ranges.

Table 5.8-2. Waterborne Traffic Projections above Ice Harbor Lock 2002-2022 (in thousand tons)[1/]

Commodity Group	2002	2007	2012	2017	2022
Grain	3,647	3,799	3,798	3,892	4,052
Wood Chips and Logs	694	694	694	694	694
Wood Products	66	79	101	128	148
Petroleum	127	136	145	156	167
Other	97	110	128	148	167
Total	**4,631**	**4,817**	**4,865**	**5,018**	**5,228**

[1/] These projections are the medium or "most likely" values projected in the navigation analysis. The DREW Transportation Workgroup's analysis also provided low – "likely minimum" – and high – "likely maximum" – values for each year.

Source: DREW Transportation Workgroup, 1999 (Table 4-17).

The DREW Transportation Workgroup analysis compared the costs of transporting, storing, and handling existing and projected shipments under the base-case scenario with the costs that would be incurred if dam breaching were to occur. Grain accounted for approximately 75 percent of the tonnage passing through Ice Harbor lock in 1995 (Table 4.9-5). The DREW Transportation Workgroup analysis assumed that regional grain modal, handling, and storage capacity could be expanded to meet geographic shifts in demand without significant increases in average costs. Similarly, the analysis assumed that grain elevator throughput capacity could be increased with little impact upon average costs. Storage and handling costs for non-grain commodities were assumed to be generally equivalent under either scenario. The analysis also assumed that shipment volumes of both grain and non-grain commodities remain constant from month to month.

The DREW Transportation Workgroup analysis measured direct economic effects in terms of opportunity costs rather than market rates. In other words, the costs developed in this analysis assume a perfectly competitive market and do not take into account possible increases in rail and truck transportation rates that may occur in the absence of navigation. It was also assumed that current and projected levels of exports from the region would continue under the dam breaching scenario.

The economic effects of the loss of navigation are addressed in terms of costs associated with both current and projected future traffic volumes. Alternative routings for existing and projected lower Snake River shipments were identified based on origin and destination data compiled for each shipment. Commodities would in most cases be either rerouted via truck to river elevators located on McNary pool or shipped by rail directly to export elevators on the lower Columbia River. Where rail access is currently available at country elevators, grain would either shift to rail direct from these locations, or be moved by truck to a rail distribution point where unit trains could be assembled. The costs of transportation, storage, and handling were calculated for the alternative routings of each affected origin-destination pair.

The DREW Transportation Workgroup analysis covers a period of 100 years. The initial year of project implementation is assumed to be 2007 with effects measured from 2007 through 2106. Based on this long-term perspective, the analysis assumes that the majority of grain-producing land within the region would ultimately remain

in production. It is, however, possible that in the short-term some marginal land with a navigation-associated transportation cost advantage could be forced out of production if dam breaching were to occur. In the long run, it is assumed that this land would be purchased at a lower overall cost and, and likely still be used for agricultural production.

5.8.1.2 The Alternatives and their Effects

Under Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, and Alternative 3—Major System Improvements, existing and projected waterborne traffic would be transported by barge on the lower Snake River. The projected volumes are presented by commodity group and 5-year increments in Table 5.8-2. The following discussion compares the effects of Alternative 4—Dam Breaching with this base-case condition. The DREW Transportation Workgroup analysis does not distinguish between the short- and long-term navigation effects associated with dam breaching. Costs are presented for selected years and then extended over the 100-year period of study and converted to average annual amounts using three different rates of interest. There is, however, some uncertainty regarding the length of time that would be required for the regional transportation system to adapt to a dam breaching scenario. Loss of navigation would be an unavoidable adverse impact under Alternative 4—Dam Breaching.

The following discussion, which is based on the DREW Transportation Workgroup analysis, focuses upon grain and then addresses the remaining commodity groups.

Grain

If dam breaching were to occur, an estimated 126.6 million bushels or 3.8 million tons of grain would be diverted from transportation via the lower Snake River annually. Of this volume, approximately 1.1 million tons (36.6 million bushels or 29 percent) would shift from the river to rail for transport. The remaining 2.7 million tons (90.0 million bushels or 71 percent) would move by truck to river elevators on the McNary pool and then by barge to deep-water terminals. These projected changes are presented in bushels by state for the year 2007 in Table 5.8-3.

Table 5.8-3. Grain Diverted from the Lower Snake River in 2007 under Alternative 4—Dam Breaching

	Truck-Barge (Bushels)[1/]	Rail (Bushels)	Total (Bushels)
Idaho	11,569,804	20,720,137	32,289,941
Montana	6,537,310	-	6,537,310
Washington	68,459,852	15,895,177	84,355,029
Oregon	980,218	-	980,218
North Dakota	2,458,172	-	2,458,172
Total	**90,005,536**	**36,615,314**	**126,620,670**
Percent	**71.1**	**28.9**	**100.0**

[1/] The Truck-Barge category addresses grain that would move by truck to river elevators on the McNary pool and then by barge to deep-water terminals.
Source: DREW Transportation Workgroup, 1999 (Table 7-8).

Table 5.8-4 presents grain transportation costs under the first three alternatives and under Alternative 4—Dam Breaching and identifies the increases in transportation costs that would be associated with dam breaching. The DREW Transportation Workgroup estimates that the average cost increase to transport grain that would be displaced to more costly modes of transportation if dam breaching were to occur would be approximately 27 cents per bushel (Table 5.8-4).

Table 5.8-4. Grain Transportation Cost Comparison by State for 2007

		Alternatives 1-3		Alternative 4		Cost Difference		
State	**Bushels**	**Total Cost ($)**	**Cost Per Bushel ($)**	**Total Cost ($)**	**Cost Per Bushel ($)**	**Total Cost ($)**	**Cost Per Bushel ($)**	**% Increase**
Idaho	32,289,941	22,883,707	0.71	33,394,488	1.03	10,510,781	0.33	46
Montana[1/]	6,537,310	46,381,513	7.10	47,757,544	7.31	1,376,031	0.21	3
North Dakota	2,458,172	3,262,017	1.33	3,523,573	1.43	261,556	0.11	8
Oregon	980,218	331,837	0.34	393,165	0.40	61,328	0.06	18
Washington	84,355,029	49,255,647	0.58	70,669,483	0.84	21,413,836	0.25	43
Total	126,620,670	122,114,721	0.96	155,738,253	1.23	33,623,532	0.27	28

[1/] The high cost per bushel for Montana grain reflect the very high storage and handling costs included in the DREW Transportation Workgroup's analysis. This analysis conversely does not identify any storage or handling costs for Oregon or North Dakota. Although these estimated costs are unrealistic, they are handled consistently across the alternatives. As a result, the difference between Alternatives 1 through 3 and Alternative 4 is likely to be more realistic than the estimates for each case.

Source: DREW Transportation Workgroup, 1999 (Tables 5-13 and 6-3)

According to the DREW Transportation Workgroup's analysis, grain shipments that originate in Washington state account for about 64 percent of the total increase in grain-related transportation costs. Shipments originating in Idaho account for about 31 percent, with shipments originating in Oregon, North Dakota, and Montana accounting for the remaining 5 percent. Grain originating in Washington state accounts for 69 percent of grain shipments on the lower Snake River, with 60 percent of total shipments originating in five Washington counties—Adams, Garfield, Spokane, Walla Walla, and Whitman. Whitman County alone accounts for about 41 percent of the Washington total. The percentages of diverted grain and increased transportation costs are presented by state in Table 5.8-5 and shown graphically in Figures 5.8-1 and 5.8-2. Idaho shippers would assume a disproportionate percentage of increased cost— about 31 percent of the cost compared to 22 percent of the total shipments—due to more costly alternative transportation modes.

Table 5.8-5. Percentage of Diverted Grain and Increased Transportation Costs by State under Alternative 4—Dam Breaching

State of Origin	% of lower Snake River Barged Grain	% of Increased Transportation Costs
Oregon	1.0	0.2
Idaho	22.0	31.3
Washington	69.0	63.7
North Dakota	2.5	0.8
Montana	5.5	4.1

Source: DREW Transportation Workgroup, 1999 (Table 7-11).

Figure 5.8-1. Percent of Lower Snake River Barged Grain by State

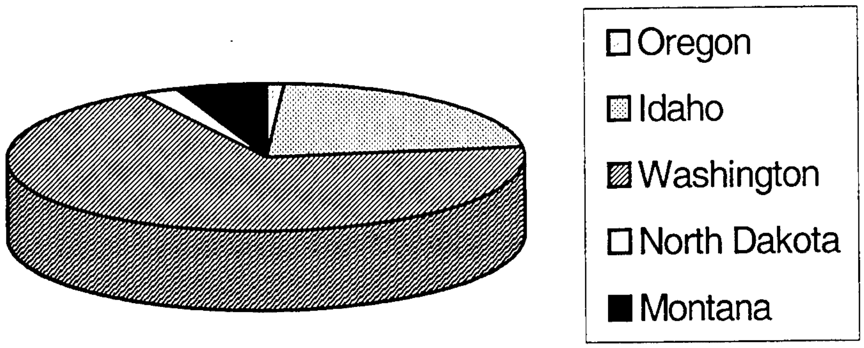
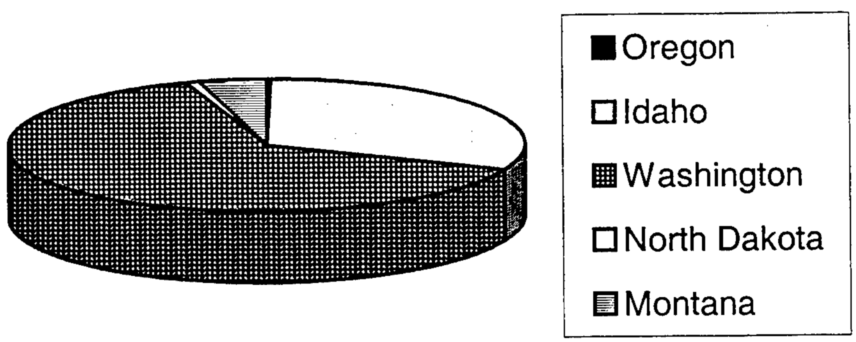


Figure 5.8-2. Percent of Increased Transportation Costs



Other Commodities

Grain accounts for about 76 percent of the waterborne traffic projections for the lower Snake River. About 18 percent of projected shipments are wood chips and logs. Wood products, petroleum products, and other commodities comprise the remaining 6 percent. Transportation costs for non-grain commodities under the base case and dam breaching scenarios are presented for 2007 in Table 5.8-6. The projected non-grain cost increases associated with dam breaching range from 3 percent for wood chips and logs to 24 percent for wood products. In comparison, the projected average change in grain transportation costs is 28 percent (Table 5.8-4).

Table 5.8-6. Non-Grain Commodity Transportation Cost Comparison for 2007

		Alternatives 1-3		Alternative 4		Cost Difference		
	Tons	Total Cost ($)	Cost Per Ton ($)	Total Cost ($)	Cost Per Ton ($)	Total Cost ($)	Cost Per Ton ($)	% Increase
Petroleum	136,000	15,893,106	116.86	16,441,562	120.89	548,456	4.03	3.45
Wood Chips and Logs	694,000	47,879,179	68.99	49,320,040	71.07	1,440,861	2.08	3.01
Wood Products	79,000	5,242,586	66.36	6,516,753	82.49	1,274,167	16.13	24.30
Other	110,000	6,946,350	63.15	7,533,960	68.49	587,610	5.34	8.46
Total	**1,019,000**	**75,961,221**	**74.54**	**79,812,315**	**78.32**	**3,851,094**	**3.78**	**5.07**

Source: DREW Transportation Workgroup, 1999 (Tables 5-15 and 6-5)

Summary

The average annual effects are presented for Alternative 4—Dam Breaching in Table 5.8-7. These values, presented in 1998 dollars, represent the net change from Alternatives 1 through 3, which serve as the base case for this analysis. Average annual costs were calculated based on a 100-year period of analysis at three discount rates—6.875 percent, 4.75 percent, and 0.0 percent. The data presented in Table 5.8-7 indicate that the majority of the average annual cost increase—about 83 percent—would be associated with grain.

Table 5.8-7. Average Annual Economic Effects by Discount Rate (000s of dollars) [1/]

	6.875 % Discount Rate	4.75 % Discount Rate	0.0 % Discount Rate
Grain	(22,566)	(22,731)	(23,156)
Non-Grain Commodities	(4,624)	(4,710)	(4,904)
Total	**(27,190)**	**(27,441)**	**(28,060)**
Adjusted Total[2/]	**(23,804)**	**(25,008)**	**(028,060)**

[1/] These numbers presented net of Alternatives 1 through 3 are negative because they are costs that would be incurred above the baseline costs projected for Alternatives 1 through 3.

[2/] The DREW Transportation Workgroup analysis used 2007 as the base year. These are the first set of average annual values. The adjusted totals discount the same stream of costs back to 2005 to allow comparability with other elements of the study.

Source: DREW Transportation Workgroup, 1999 (Tables 5-15, 6-5, and 7-6)

5.8.2 Railroads

If dam breaching were to occur, an estimated 3.8 million tons of grain would be diverted from transportation via the lower Snake River annually. About 1.1 million tons, 67.7 million bushels, or 29 percent of this total would shift from the river to rail for transport. These projected changes are presented in bushels by state for the year 2007 in Table 5.8-3. Although not directly related to actions under Alternative 1—Existing Conditions, the continued presence and operation of the lower Snake River portion of the Columbia-Snake Inland Waterway may continue to exert pressure on the viability of railroads and historic trends in railroad abandonment may continue throughout the lower Snake River region.

The DREW Transportation Workgroup analysis assumed that regional modal, handling, and storage capacity could be expanded to meet geographic shifts in demand without significant increases in average costs. In the case of rail, there is some uncertainty as to whether sufficient capacity exists to accommodate the projected increase in demand associated with Alternative 4—Dam Breaching. The following sections address potential effects to mainline and short-line railroads, railcar capacity, and unloading capacities at export and country elevators.

5.8.2.1 Mainline Railroads

Both mainline railroads, Burlington Northern-Santa Fe and Union Pacific, would be impacted by dam breaching through the shift of grain and other commodities from the lower Snake River to rail. The DREW Transportation Workgroup analysis assumed that all commodities shifted to rail would eventually require the services of these

mainline carriers to reach their final destinations at ports on the lower Columbia River. The increase in grain shipments alone would increase traffic on the mainline routes from about 840 to about 940 railcar-trips per month. Assuming a train size of 108 cars, this represents an increase of from about eight to nine additional trains per month destined to ports on the lower Columbia River. This would be a significant increase in rail traffic and improvements to the existing mainline system may be needed.

Estimates of diverted traffic and generic (or "rule of thumb") measures were used by civil engineers at the University of Tennessee's Transportation Center to estimate the costs of construction or modification of mainline railroad infrastructure. Costs to modify or construct line-haul rail trackage were estimated to range from $14 to $24 million. These costs, which were discussed with engineering professionals from a number of railroads, discussed with experts from private construction firms routinely engaged in rail project construction, and reviewed by local rail officials from Burlington Northern-Santa Fe, Union Pacific, and others, do not include rail line improvement costs at port or railhead facilities. Costs that would be required to stabilize roadbeds, embankments, bridges, and track in the event of dam breaching are also not included in this estimate. Stabilization costs are included in the cost of project implementation (see Technical Appendix I, Economics for a discussion of implementation costs).

A study conducted by the Tennessee Valley Authority (TVA) and Marshall University evaluated the impact of the costs of projected infrastructure improvements on mainline railroads and concluded that these improvements could be made by the railroads without putting any upward pressure on long-run costs or rates (TVA and Marshall University, 1998). This study assumed that all commodities now moving on the lower Snake River would be diverted to rail, a worst-case scenario. The TVA and Marshall University study also addressed the concern that the projected increase in rail traffic could potentially cause congestion on mainline railroads. This study concluded that there would not be increases in delays due to congestion if necessary system improvements are made. The potential for congestion was also reviewed by transportation analysts at two mainline railroads.

5.8.2.2 Short-Line Railroads

Detailed cost estimates of improvements that would be required for short-line railroads were not developed as part of the DREW Transportation Workgroup analysis. Information was, however, compiled from a transportation impact study prepared for the Washington State Legislative Transportation Committee (HDR Engineering, Inc. [HDR], 1999). Representatives of the potentially affected railroads were also contacted and asked to identify any improvements that might be required. Identified improvements are estimated to range from $19.9 million to $23.8 million. These estimates are currently being reviewed by the affected railroads.

5.8.2.3 Rail Car Capacity

There is presently a large surplus of grain cars in the region. The grain car utilization rate for the Burlington Northern Santa Fe railroad was, for example, only about 50 percent in June 1999. The DREW Transportation Workgroup assumed that additional cars would, however, be required in the long-run to accommodate the shift

of 1.1 million tons of grain from barge to rail if dam breaching were to occur. The number of additional railcars would range from 280 to 670 depending on the monthly turn around rate. The cost of these additional cars would range from $14 million to $36.8 million.

5.8.2.4 Export and Country Elevators

Based on an analysis of monthly rail car unloadings at Columbia River elevators from 1988 to 1997, the DREW Transportation Workgroup concluded that existing unloading capacity would be sufficient to accommodate the increased rail shipments of grain that would occur if dam breaching were to occur (DREW Transportation Workgroup, 1999). Additional storage would, however, be necessary to accommodate from 140 to 325 additional railcars. The estimated costs associated with providing this storage range from $2.0 million to $4.0 million.

The DREW Transportation Workgroup also concluded that current capacity at country elevators would be adequate to accommodate changes in shipping patterns associated with Alternative 4—Dam Breaching. However, the costs for improvements to upgrade railhead facilities in Washington were estimated to range from about $14.0 million to $16.9 million. Loading and unloading facilities at railhead country elevators in Idaho are considered to be adequate to accommodate the increase in rail shipment without any improvements (DREW Transportation Workgroup, 1999).

5.8.2.5 River Elevator Improvements

The DREW Transportation Workgroup analysis suggests that about 2.7 million tons (90 million bushels) of grain diverted from the lower Snake River would be shipped via truck to the Tri-Cities area, where it would be loaded on barges and shipped to export elevators via the lower Columbia River. Additional grain storage capacity required in the Tri-Cities area would range from 10.8 million to 36 million bushels, depending on the storage turnover ratio. Costs to provide this storage are estimated to range from $58.7 million to $335.4 million depending on the type of facility. These estimates include the cost of rail trackage and access roads (DREW Transportation Workgroup, 1999).

5.8.3 Highways

Under Alternative 4—Dam Breaching, about 3.8 million tons of grain would be diverted away from the lower Snake River each year. According to the DREW Transportation Workgroup's analysis, approximately 71 percent or 2.7 million tons of this volume would move by truck to river elevators on McNary pool and then by barge to deepwater terminals. These projected changes are presented in bushels by state for the year 2007 in Table 5.8-3. Projected increases in truck bushel miles are presented by state in Table 5.8-8. Projected changes range from a decrease of about 1.4 million truck miles in Idaho to an increase of nearly 2.6 million truck miles in Washington. The decrease in Idaho is explained by the shift of grain to rail. The increase in Washington is largely the result of a change in the destination of truck shipments from ports on the lower Snake River to ports in the Tri-Cities area.

Table 5.8-8. Projected Changes in Truck Miles by State

State	Sum Of Total Bushels	Increase in Bushel-Truck Miles	Increase in Truck Miles [1/]
Idaho	24,271,500	(1,235,193,157)	(1,419,762)
Oregon	736,804	30,198,573	34,711
Washington	63,407,459	2,577,756,664	2,962,939
Montana	4,913,924	757,607,372	870,813
N. Dakota	1,847,743	265,297,487	304,940
Totals	95,177,430	2,395,666,939	2,753,640

[1/] Number of bushels per truck equals 870.

Source: DREW Transportation Workgroup, 1999 (Table 6-12)

5.8.3.1 Highway Infrastructure Investment

A transportation analysis prepared as part of the Eastern Washington Intermodal Transportation Study (EWITS) (Jessup and Casavant, 1999) addressed eight possible grain transportation scenarios that may result if dam breaching were to occur. These scenarios were intended to cover a wide range of potential responses by rail and barge companies. Potential scenarios considered range from no quantity constraints on the volume of rail shipments and no price response from rail or barge companies (Scenario 2) through rail grain shipments being constrained to 110 percent of historical volume and both rail and barge rates increasing by 10 percent.

The following discussion draws on Jessup and Casavant's (1999) Scenario 4, which assumes that rail grain shipments would be constrained to 110 percent of historical volume and rail companies would increase their shipping rates by 10 percent. That study only addressed eastern Washington grain shipments.

Impacts on highway capital and maintenance costs with dam breaching were determined on the basis of the change in the use of highways to transport grain. The change in highway use was computed as the change in truck miles if dam breaching were to occur. Maintenance cost savings for Idaho were not estimated, and the change in truck miles for Oregon was considered to be too small to be significant. In the case of Washington, costs include miles for grain movements from Montana and North Dakota because the increase in highway traffic would actually occur in Washington.

Highway Infrastructure Improvement Needs

Highway improvements that were identified as necessary to maintain adequate highway performance and minimal travel delay include intersection improvements, pavement replacement or overlay, and more frequent maintenance.

Neither the DREW Transportation Workgroup nor the Washington State Legislative Committee report addressed the additional operations and maintenance costs created by the increased truck miles identified in Table 5.8-8. The EWITS study identified additional annual costs to Washington State highways under drawdown conditions (Jessup and Casavant, 1999). Although this study did not include grain movements from other states nor does it use the same data as the DREW Transportation Workgroup, it does provide an indication of the lower level of annual costs needed to maintain Washington State highways.

If dam breaching were to occur, there would be a substantial change in highway shipments of Washington grain. Truck wheat shipments would no longer collect in corridors to river ports on the lower Snake River as they would under Alternative 1. Rather they would be rerouted to river elevators located on McNary pool downstream of the affected river segment. Truck shipments would rely on different highways to reach river ports located on or below the McNary pool. State Routes (SRs) 395 and 17 would support heavy wheat flows from the north, while SR 26 and SR 260 would support heavy east-to-west truck shipments. These state routes and Interstates 90 and 82 would also support heavy flows of barley heading to river ports at or below the Tri-Cities or cattle feedlots in the Columbia River Basin (Jessup and Casavant, 1999).

Total wheat and barley highway flows would increase from a base case condition of 436 million tonmiles under Alternative 1—Existing Conditions to 724 million tonmiles under Alternative 4—Dam Breaching (Table 5.8-9). State highways in Washington would experience the largest growth in grain tonmiles, with an increase of approximately 283 million tonmiles or 91.3 percent. According to Jessup and Casavant (1999), this would involve an annual increase of 91.3 percent or $2.8 million in state highway infrastructure investment. Annual interstate highway investments would increase by 39 percent or $22,655, while county highway infrastructure investments would decrease by 5.9 percent or $228,249 (Table 5.8-9).

Table 5.8-9. Tonmile and Infrastructure Investment by Highway Type

	Tonmiles	Percent of Total Tonmiles	Infrastructure Investment ($)	Percent of Infrastructure Investment
Alternative 1—Existing Conditions[1]				
Interstate	29,053,431	6.7	58,089	0.8
State	309,597,521	71.1	3,096,555	44.0
County	96,983,339	22.3	3,879,296	55.2
Total	**435,634,291**		**7,033,940**	
Alternative 4—Dam Breaching[2]				
Interstate	40,375,491	5.6	80,744	0.8
State	592,350,787	81.8	5,923,507	61.3
County	91,277,914	12.6	3,651,047	37.8
Total	**724,004,192**		**9,655,298**	
Net Change		**Percent Change**[3]		**Percent Change**[3]
Interstate	11,322,060	39.0	22,655	39.0
State	282,753,266	91.3	2,826,952	91.3
County	-5,705,425	(5.9)	-228,249	(5.9)
Total	**288,369,901**		**2,621,358**	

[1] Jessup and Casavant's Scenario 1. .
[2] Jessup and Casavant's Scenario 4.
[3] This figure is the percent change between Alternative 1 and Alternative 4.
Source: Jessup and Casavant, 1999 (Tables 7, 16, 34, and 41).

Under Alternative 1—Existing Conditions, grain shipments from Idaho, Montana, and North Dakota are transported via barge from Lewiston, Idaho. If dam breaching were to occur, these shipments would be moved by truck to river ports below Ice Harbor Dam. These movements are not included in Jessup and Casavant's (1999) analysis,

which only addresses eastern Washington grain shipments. Shipments of Idaho grain would concentrate along three primary highway corridors in Washington—SR 12 and County Road 124 (CR 124), SR 26 and SR 395, and Interstate/SR 395. Grain shipments from Montana and North Dakota would likely take the Interstate/SR 395 corridor. Increased tonmiles per corridor were multiplied by Jessup and Casavant's highway cost coefficients, which vary by type of highway. Upper range estimates of increased infrastructure investment suggest that the SR 12/CR 124 corridor would require an additional $1,924,055 in annual infrastructure investments to accommodate increased truck traffic originating outside Washington state. The SR 26/SR 395 and Interstate/SR 395 corridors would require increased annual infrastructure investments of $204,858 and $106,477, respectively.

While Washington highways would experience substantial increases in tonmiles if dam breaching were to occur, the analysis indicates that Idaho would experience a significant decrease in tonmiles under Alternative 4—Dam Breaching. This is especially the case with grain that currently moves north via I-95 to the Port of Lewiston.

In addition to these estimates of annual operations and maintenance costs, the report prepared for the Washington State Legislative Transportation Committee (HDR, 1999) estimated one time capital costs for improvements necessary to maintain adequate highway performance, improve intersections, and replacement or upgrade pavement. This report addressed two scenarios—a maximum highway impact scenario and a maximum railroad impact scenario. The maximum highway impact scenario assumes that transportation costs would remain constant relative to one another and that current rail shortages would continue. All grain shipments presently currently arriving in Lewiston from southern Idaho are assumed to continue to move to Lewiston. Under this scenario, if dam breaching were to occur, these grain shipments would move by way of U.S. Highway 12 into Washington state, to ports at or below the Tri-Cities. HDR's maximum rail transportation scenario assumes a 10 percent decrease in rail costs relative to truck/barge transportation. Ranges of one-time highway costs developed by HDR are presented for both scenarios in Table 5.8-10. These estimates represent extreme minimum and maximum potential cost increases. Actual highway improvement costs incurred under Alternative 4—Dam Breaching would likely be somewhere between these estimates.

Table 5.8-10. One-Time Highway Costs under Alternative 4—Dam Breaching

	Intersection Improvement ($ million)	Pavement Improvement ($ million)	Total ($ million)
Highway Scenario	8.9 - 10.6	75.2 - 90.1	84.1 - 100.7
Railroad Scenario	8.9 - 10.6	47.1 - 56.5	56.0 - 67.2

Source: HDR, 1999 (Appendix B, TM No. 6, Tables 2 and 5).

The total estimated costs for short-term transportation infrastructure improvements required under dam breaching are presented in Table 5.8-11.

Table 5.8-11. Summary of Estimated Costs of Infrastructure Improvements Needed with Dam Breaching

Infrastructure Improvements	Estimated Costs ($ thousand) Low	High
Mainline Railroad Upgrades	14,000	24,000
Short-Line Railroad Upgrades	19,900	23,800
Additional Rail Cars	14,000	26,850
Highway Improvements	84,100	100,700
River Elevator Capacity	58,700	335,400
Country Elevator Improvements	14,000	16,900
Export Terminal Rail Car Storage	1,985	4,053
Total	**206,685**	**531,703**

5.8.3.2 Traffic Congestion and Safety

Congestion

If dam breaching were to occur, traffic congestion could occur along the highway corridors that would experience significant increases in truck traffic. Potential congestion impacts are most likely to occur along the SR 12/CR 124, SR 26, and SR 395 corridors. Traffic flow estimates, existing traffic flows, and the increases are presented in Table 5.8-12. Based on this analysis, the most significantly affected highway would be SR 26 from Colfax to the Tri-Cities. Potential truck traffic increases on this route are estimated at 108 percent, with total traffic increasing by approximately 13 percent.

Table 5.8-12. Traffic Increases for Selected Highways under Alternative 4—Dam Breaching

Affected highways	Estimated Average Trucks per day[1/]	Existing Truck Traffic[2/]	Existing Vehicle Traffic	% Increase in Existing Truck Traffic	% Increase in Existing Total Traffic
SR 12/CR 124	85	519	3,450	16	2
SR 26	129	120	1,010	108	13
SR 395	76	3,360	12,700	2	1
395 & 26 Combined	205	3,360	12,700	6	2

[1/] These estimates assume that approximately 5 million bushels of wheat and barley that currently move through Lewiston would be diverted to alternate modes of transportation in southern Idaho. These estimates model also assume that approximately 10.3 million bushels of displaced wheat and barley originating in Idaho and 12.1 million bushels originating in eastern Washington would move by rail to Portland rather than by truck to the Tri-Cities. This estimate does not include the movement of other commodities and is limited to grain.

[2/] Existing truck and vehicle traffic counts are from the 1996 Washington State Department of Transportation Average Daily Traffic counts. Traffic Estimates are from milepost 22 for SR 395, at the junction of SR 12 and SR 395 in Pasco, milepost 0 on CR 124 in Burbank, and milepost 294 on SR 26 near the junction of SR 260.

Source: Foster Wheeler Environmental, 1999 (Social Analysis Report).

Traffic in Idaho would decrease on U.S. 12 over Lolo Pass as would northbound traffic on U.S. 195 from southern Idaho to Lewiston. There would also be less traffic on local county roads that currently handle truck movements to lower Snake River ports.

Another way of estimating the total potential increased truck traffic in the region is to divide the total number of bushels projected to move by truck under dam breaching by 1,000 bushels (assuming a truck capacity of 1,000 bushels [30 tons] of grain per truckload). Under existing volumes, approximately 71,264,669 bushels of grain would be displaced to trucks. Therefore, with dam breaching there would be an increase of approximately 71,265 annual truck trips to the Tri-Cities area in Washington. Further assuming 252 days for grain delivery per year, this represents approximately 274 trucks per day or 34 trucks per hour across the roads of Eastern Washington. With the implementation of the highway improvements identified in the Drew Transportation Workgroup report, highway congestion should not increase. However, additional, more detailed, engineering and traffic studies would be required to determine what highway improvements would actually be needed.

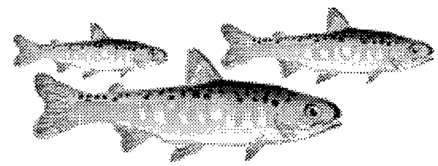
Safety

Safety and accident estimates are based on accident rates per million truck miles. Each mode of transporting commodities—truck, barge, and rail—has a distinct safety history. Rail and barge accident rates are almost identical, while trucking accident rates are higher by several orders of magnitude. State accident data for non-interstate roads in Washington state are estimated at 1.9 accidents per million miles for tractor semi-trailer and tractor double-trailer trucks. Fifty percent of these accidents involve property damage, 1.37 percent of accidents involve fatalities, and 49.39 percent of accidents involve injury (U.S. Department of Transportation, 1995). Total truck miles estimated from the Corps transportation model were converted to million truck miles and multiplied by the accident rate coefficients for selected highways that would likely see the greatest increase in truck traffic under Alternative 4—Dam Breaching (Table 5.8-13). Total accident data for 1996 are presented in Table 5.8-13 for comparison (Washington Department of Transportation, 1997).

The increased accidents presented in Table 5.8-13 are directly related to the increase in truck miles. As a result, the portion of U.S. 26 from Colfax to SR 396 would experience the greatest increase in accidents. Accidents in Idaho would likely decrease as truck traffic is diverted to more expensive but closer rail loading facilities.

Table 5.8-13. Estimated Traffic Accidents by Selected Highway under Alternative 4—Dam Breaching

Main Alternative Highway	Total Bushels Shipped on the lower Snake River	Million Truck Miles	Projected Annual Accidents	Annual Fatalities	Annual Injuries	Annual Property Damage Incidents	Total 1996 Accidents	Projected Annual Accidents as a % of 1996 Accidents
Displaced to Rail	19,590,427	-2.91	-5.53	-0.08	-2.73	-2.76	N/A	-
SR 395 Ritzville to Tri-Cities	15,860,145	1.29	2.45	0.03	1.21	1.22	145	1.7
SR 12/124 Clarkston to Burbank	22,309,052	1.44	2.74	0.04	1.35	1.37	318	0.9
SR 26 Colfax to 395	36,433,449	2.47	4.69	0.06	2.32	2.34	53	8.8
Total Change			4.35	0.06	2.15	2.18		-



5.9 Electric Power

The four lower Snake River dams are part of an integrated system of hydroelectric facilities located throughout the Columbia River Basin. This system provides a number of products and services, including firm and non-firm energy, peak, and sustained capacity; daily load-following capacity; and other attributes that contribute to the reliability of the regional power system (see Section 4.10, Electric Power). Changing system hydropower operations affects the ability of the regional power system to generate electricity and the cost of generating that electricity. Changing hydropower operations also affects system reliability and capability, transmission, and ancillary services. The potential effects of the alternatives on electric power are summarized in Table 5.9-1.

Changes in the regional power system's ability to provide energy and capacity, and the costs of providing these products, form the core of the power system impact analysis conducted by staff members of the Corps and BPA for this FR/EIS. An oversight group, the Drawdown Regional Economic Workgroup Hydropower Impact Team (DREW HIT), was formed to assist in the analysis and provide a forum for interested parties to provide input. The majority of the information presented in the following sections is drawn from the 1999 DREW HIT report entitled *Technical Report on Hydropower Costs and Benefits* (DREW HIT, 1999). A more detailed discussion of the methodology and findings of the portion of the DREW HIT analysis that addresses net economic costs is provided in Technical Appendix I, Economics.

Table 5.9-1. Summary of Potential Effects of the Alternatives on Electric Power

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Power generation	Power generation would increase as projected by power needs.	Same as Alternative 1.	Same as Alternative 1.	The four lower Snake River hydropower facilities would no longer be operated or produce hydropower, creating the need for replacement power.
Financial impacts to ratepayers	There would be no significant changes in rates.	Same as Alternative 1.	Same as Alternative 1.	Increases in monthly power bills are likely.

5.9.1 Methodology

The overall goal of the DREW HIT study was to develop an estimate of the net economic effects associated with the changes in hydropower under each of the alternatives. This involved a number of steps. The first step involved using system hydroregulation studies to estimate how much hydropower generation would occur under the different alternatives and under different water conditions. This information was then incorporated into three different power system models to estimate how changes in hydropower generation would affect generation from other more costly power resources (Figure 5.9-1). The effects of these hydropower changes on the market price of electricity over time were also estimated. In addition, this analysis investigated the potential financial impacts of these changes on regional ratepayers. The power system modeling tools were also used to help identify the changes in air pollutant emissions associated with the different alternatives. The potential effects of the alternatives on air emissions are addressed in Section 5.2, Air Quality.

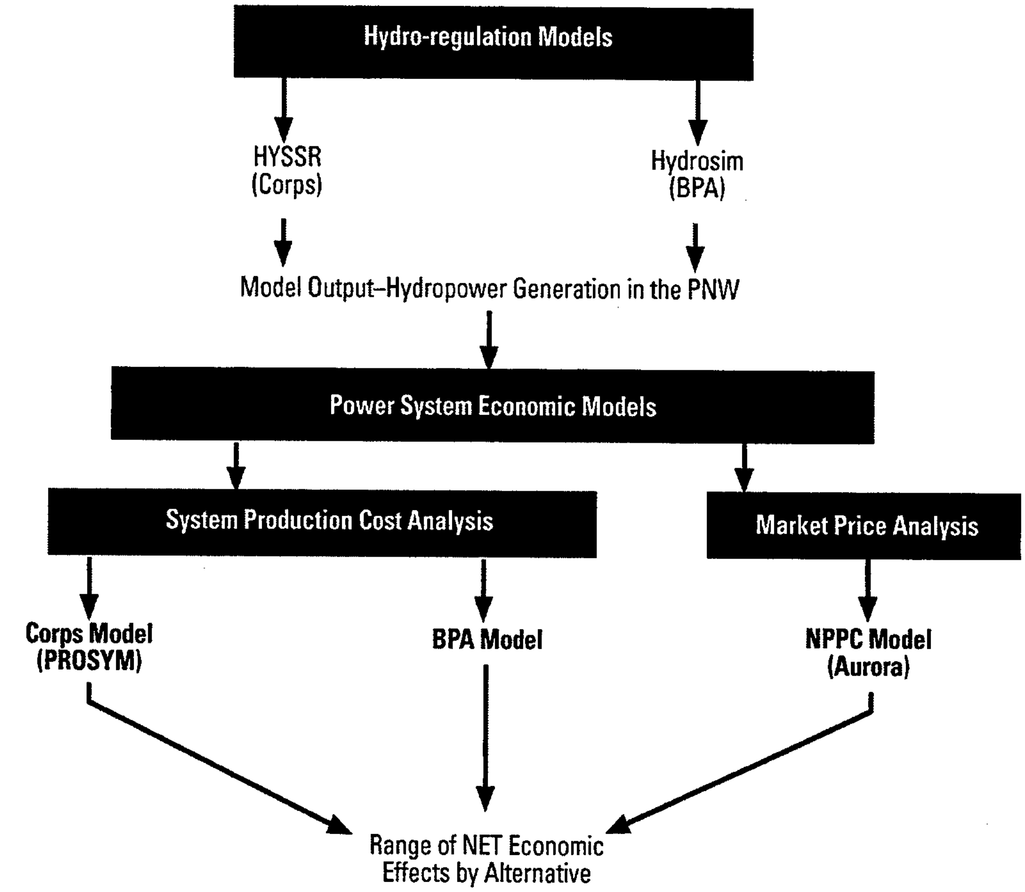
The entire electrical industry has been undergoing significant changes from the regulated industry of the past to a partially competitive industry. The Federal Energy Regulatory Commission (FERC) opened wholesale electric power markets to competition by requiring utilities that own, control, or operate transmission lines to offer others the same electricity transmission service that they provide themselves. Open transmission access improves the flexibility to purchase electricity from generation facilities located throughout the Western Systems Coordinating Council (WSCC) area.

5.9.1.1 Hydro-Regulation Models

Changes in hydropower production were evaluated for this study on a system-wide basis. Two hydro-regulation models—the Corps' Hydro System Seasonal Regulation Program (HYSSR) and BPA's Hydro Simulator Program (HYDROSIM)—were used to estimate how much hydropower generation would occur under different alternatives and water conditions. These models simulate 50 and 60 historic water years and provide estimates of month-by-month hydropower generation in the Pacific Northwest for each of these years.

5.9.1.2 Power System Models

The hydro-regulation modeling results were incorporated into three power system models to estimate the net economic costs associated with each alternative. Three models that have been used in other studies by the Corps, BPA, and the Northwest Power Planning



Source: Modified from DREW HIT, 1999 (Figure 9)

Figure 5.9-1. Schematic of the Models Used in the DREW HIT Analysis

Council (NPPC) were used to assure that the cost estimates were adequately bracketed. The Corps model (PROSYM) and the BPA model evaluate annual net economic effects using a system production cost analysis approach. The NPPC model (Aurora) employs a market price analysis approach. These two approaches are discussed in more detail in Technical Appendix I, Economics.

The net economic costs developed for this study consist of three components: 1) annual net economic effects determined by system production costs or market-clearing prices, 2) transmission reliability costs, and 3) ancillary services.

System Production Costs Analysis

The system production cost analysis identifies net economic effects by comparing the production costs of using different forms of energy production. Changes in hydropower generation result in different levels of operation of more costly thermal generating power plants.

Projected resource additions based on the BPA model results are presented for 2010 and 2018 in Table 5.9-2. New generating units are assumed to be natural gas-fired combined cycle units. System production costs were calculated for each alternative based on this information.

Table 5.9-2. Power Resource Additions by Alternative for Selected Years

	2010			2018		
Alternative[1/]	PNW (aMW)	PSW (aMW)	Total (aMW)	PNW (aMW)	PSW (aMW)	Total (aMW)
Existing Conditions	5,390	3,260	8,650	8,720	8,770	17,490
System Improvements	5,380	3,190	8,570	8,710	8,760	17,470
Dam Breaching	6,210	3,260	9,470	9,700	8,750	18,450
Difference from Base Condition (aMW)						
System Improvements	(10)	(70)	(80)	(10)	(10)	(20)
Dam Breaching	820	-	820	980	(20)	960
Difference from Base Condition (MW)						
System Improvements	(10)	(80)	(90)	(10)	(10)	(20)
Dam Breaching	890	-	890	1,070	(20)	1,040

[1/] The system improvements estimates apply to both Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 3— Major System Improvements.
( ) = negative, PNW = Pacific Northwest, PSW = Pacific Southwest, MW = Megawatts, aMW = average Megawatts
Source: DREW HIT, 1999 (Table 25).

Market Price Analysis

The market price analysis approach calculates net economic effects by multiplying projected market prices by the changes in hydropower output from the base condition. Future market prices were estimated using the NPPC Aurora model. This model estimates prices by using hourly demands and individual resource characteristics to determine which generating resources are needed for each area in any given hour.

Summary of Analysis

The three models used for this analysis—Corps (PROSYM), BPA, and NPPC (Aurora)—are similar but vary in scope. The results from the BPA and NPPC models served as the primary estimate of net economic effects for all alternatives and water years. The Corps model was used to confirm results from the other models, test study assumptions, evaluate Alternative 4—Dam Breaching, and to estimate air quality impacts. The net economic effects computed from the three models were very close to one another.

5.9.1.3 Transmission Reliability

The Pacific Northwest electricity transmission grid was originally constructed in combination with the generation system. Since the transmission and generation systems interact electrically, the loss of hydropower generation would affect the transmission system's ability to move bulk power and serve regional loads. Removal of the lower

Snake River dams would, therefore, impact the reliability of the transmission system. The DREW HIT analysis developed estimates of the costs associated with maintaining transmission reliability at the current level.

5.9.1.4 Ancillary Services

Ancillary services are the benefits provided by hydropower facilities that are not reflected in the energy and capacity values discussed above. Hydropower has traditionally been acknowledged to have an advantage over most thermal units because of its ability to start quickly, to follow load, to act as a capacitor or inductor to improve system power factors, and in other ways to contribute flexibility to power systems. The value of these ancillary services estimated in the DREW HIT analysis was based on the revenue that BPA receives for marketing these services from the Lower Snake River Project.

5.9.2 The Alternatives and Their Impacts

A range of net economic effects was estimated based on the different power system models and different assumptions of future economic conditions. These effects are presented for Alternatives 2 through 4 in Table 5.9-3. These values, presented in 1998 dollars, represent the net change from Alternative 1—Existing Conditions. A negative value indicates that the alternative has a higher cost or less benefit than Alternative 1—Existing Conditions. Each alternative was analyzed using 2005 as the base year. Average annual costs were calculated based on a 100-year period of analysis at three discount rates–6.875 percent, 4.75 percent, and 0.0 percent. The different discount rates had little effect on the net average annual costs of each alternative. The point estimates discussed below are based on the 6.875 percent discount rate.

Table 5.9-3. Average Annual Economic Effects by Discount Rate (000s of Dollars)

	6.875 % Discount Rate		4.75 % Discount Rate		0.0 % Discount Rate	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Alternatives 2 and 3						
System Costs	10,000	7,000	10,000	7,000	9,000	7,000
Transmission Reliability Costs	0	0	0	0	0	0
Ancillary Services Costs	0	0	0	0	0	0
Total Costs	***10,000***	***7,000***	***10,000***	***7,000***	***9,000***	***7,000***
Total Cost Point Estimate	***8,500***		***8,500***		***8,000***	
Alternative 4						
System Costs	(221,000)	(255,000)	(220,000)	(256,000)	(217,000)	(260,000)
Transmission Reliability Costs	(22,000)	(28,000)	(19,000)	(24,000)	(16,000)	(18,000)
Ancillary Services Costs	(8,000)	(8,000)	(8,000)	(8,000)	(8,000)	(8,000)
Total Costs	***(251,000)***	***(291,000)***	***(247,000)***	***(288,000)***	***(241,000)***	***(286,000)***
Total Cost Point Estimate	***(271,000)***		***(267,500)***		***(263,500)***	

Source: DREW HIT, 1999 (Table 37).

5.9.2.1 Alternative 1—Existing Conditions

This alternative was considered the base condition for the purpose of the DREW HIT analysis. The results of the analysis for the other alternatives are compared with this

condition. Projected increases in existing generation capacity under this alternative are presented in Table 5.9-2.

5.9.2.2 Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 3—Major System Improvements

The DREW HIT analysis evaluated Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 3—Major System Improvements as one cumulative alternative. The minor differences in generation that might occur between the two alternatives were not addressed in the DREW HIT analysis.

Based on the DREW HIT analysis, this alternative would result in increases in system hydropower generation. It is not expected that the transmission system would be impacted with this alternative, and the changes in ancillary services are considered to be minimal. The average annual economic effect associated with Alternatives 2 and 3 would be a $9 million cost saving or benefit compared to Alternative 1—Existing Conditions.

5.9.2.3 Alternative 4—Dam Breaching

Under Alternative 4—Dam Breaching, the four hydropower facilities would no longer be operated, natural river levels would exist, and no hydropower generation would occur at the four lower Snake River dams. This would be an unavoidable adverse impact. The analysis of this alternative did not include any hydropower impacts that may occur with changes in irrigation withdrawal from the lower Snake River reservoirs. The point estimate of average annual net economic costs consists of three components: 1) the point estimate of system costs is $238 million, 2) the point estimate of transmission reliability costs is $25 million, and 3) the estimate of ancillary service costs is $8 million. This results in annual total net economic costs of $271 million. The following section addresses potential financial impacts to ratepayers if dam breaching were to occur. There would be no significant changes in rates under the other three alternatives.

5.9.3 Financial Impacts to Ratepayers under Alternative 4— Dam Breaching

It is not possible to say for sure how the costs associated with Alternative 4—Dam Breaching would ultimately be paid. Before restructuring of the electricity industry, a large portion of the costs would have been BPA's responsibility and BPA would have raised its rates to recover increased costs. In a restructured, competitive wholesale power market, the price that BPA can charge its customers is effectively capped by the market price of electricity. BPA can no longer recover higher costs by raising its rates because utilities that buy power from BPA now have alternate sources of electricity supplied by the wholesale electricity market.

The following discussion addresses the potential financial impacts of dam breaching to ratepayers based on a number of different cost distribution scenarios. The purpose of this discussion is to illustrate the magnitude of the costs associated with changes in hydropower operation by providing some examples of the effects on consumers under different assumptions. It is not intended to determine where the financial impacts of these costs will be distributed. An illustration of the effect of spreading the cost over all BPA customers, for example, is not meant to imply that this is a likely or even possible scenario.

The following analysis provides examples of the cost to consumers for one year, 2010, using a discount rate of 6.875 percent. Costs would be distributed by load. Four possible load scenarios are addressed in this analysis:

> **Load 1**—The entire Pacific Northwest load, which is projected to be 25,457 aMW or 223,003,320 MWh in 2010.
>
> **Load 2**—Regional consumers who have benefited from Federal hydroelectric power, either through direct purchases from BPA or through a mechanism called the regional exchange. This would exclude the commercial and industrial customers of regional investor-owned utilities. These customers constitute about 30 percent of the total regional load. The remaining load—70 percent—is projected to be 17,820 aMW, or 156,103,200 MWh in 2010.
>
> **Loads 3 and 4**—BPA customers. Two possibilities are examined here: allocating costs over all BPA sales (Load 3); or allocating costs over only BPA's firm, cost-based sales (Load 4). BPA sales under average water conditions are approximately 10,540 aMW or 92,330,000 MWh per year. However, loss of the lower Snake River facilities would reduce this generation by about 1,250 aMW under average water conditions. With the removal of the lower Snake River dams, annual BPA sales would therefore be about 9,290 aMW or 81,380,000 MWh. BPA firm sales are approximately 8,200 aMW or 71,832,000 MWh. Loss of the lower Snake River facilities would reduce BPA firm sales by about 760 aMW under critical water conditions, so BPA firm sales would be about 7,440 aMW or 65,174,000 MWh.

In addition to increased power costs, there is the question of how the costs of implementing the alternatives will be distributed. This question will ultimately be answered by Congress in the legislation that authorizes the selected alternative. Two possible scenarios are examined here. The first scenario assumes that BPA would repay hydropower's share of the implementation costs, which would be approximately 90 percent of total costs. The second scenario assumes that the nation's taxpayers would pay all the implementation costs. Implementation costs used for this analysis are net of the costs that would occur if Alternative 4—Dam Breaching were not implemented. If Alternative 4—Dam Breaching is not implemented, investments will have to be made over time to maintain and repair the dams.

5.9.3.1 Possible Power Rate Increases

Possible power rate increases based on the various loads, repayment scenarios, and additional power system costs are presented in Table 5.9-4. Possible average wholesale rate increases to power customers could range from 0.67 to 5.86 mills/kWh. It is difficult to determine how these increased wholesale rates would translate into increases in monthly power bills for different customers. Each utility purchases different amounts of BPA's wholesale electricity to serve its residential, commercial, agricultural, and industrial customers. Some Pacific Northwest utilities purchase almost no power from BPA and therefore the rate increases would be very minimal to the customer. Other utilities, however, rely exclusively on purchases from BPA, and the potential rate increases identified in Table 5.9-4 could be passed directly to the customer.

Table 5.9-4. Possible Wholesale Rate Impacts under Alternative 4—Dam Breaching[1/]

	Low	Medium	High
Implementation Costs Allocated to Hydropower (000s dollars)[2/]			
Implementation Costs	19,620	19,620	19,620
System Power Costs	220,000	288,000	362,000
Total Costs	239,620	307,620	381,620
Possible Rate Increase (mills/kWh)			
Load 1	1.07	1.38	1.71
Load 2	1.54	1.97	2.44
Load 3	2.94	3.78	4.69
Load 4	3.68	4.72	5.86
Implementation Costs not Allocated to Hydropower (000s dollars)			
Implementation Costs	(71,280)	(71,280)	(71,280)
System Power Costs	220,000	288,000	362,000
Total Costs	148,720	216,720	290,720
Possible Rate Increase (mills/kWh)			
Load 1	0.67	0.97	1.30
Load 2	0.95	1.39	1.86
Load 3	1.83	2.66	3.57
Load 4	2.28	3.33	4.46

[1/] These costs calculated using a 6.875 percent discount rate are presented net of Alternative 1—Existing Conditions in 1998 dollars.

[2/] These implementation costs were based on low, medium, and high forecasts of fuel prices, demand for electricity (loaded and efficiency of future generating resources).

Source: DREW HIT, 1999 (Table 42).

The top portion of Table 5.9-4 shows the scenario that would involve BPA paying 90 percent of the net implementation costs. Under this scenario, BPA would have $19.6 million more annual repayment costs under Alternative 4—Dam Breaching than under Alternative 1—Existing Conditions. This figure is based on a 6.875 percent discount rate. The bottom portion of the table shows that if BPA is not required to pay for the dam breaching implementation costs, they would have an annual repayment saving of about $71.3 million at a 6.875 percent discount rate. This is because, under this scenario, the dams would be removed and BPA would have no further costs.

5.9.3.2 Possible Monthly Bill Increases

Possible average monthly electricity bill increases are shown by sector in Table 5.9-5. These figures are based on 1995 electricity consumption data compiled by the NPPC and assume that wholesale rate increases would pass on to the different consumer sectors. This would not happen in all cases, but increases are presented here for illustrative purposes. This table is based on the 6.875 percent discount rate and assumes that hydropower will repay 90 percent of the implementation costs.

Table 5.9-5. Possible Monthly Bill Increases by Sector under Alternative 4—Dam Breaching

Sector	Consumption (kWh/Month)	Monthly Bill Increase[1/] Low ($/month)	Medium ($/month)	High ($/month)
Load 1				
Residential	1,113	1.2	1.5	1.9
Commercial	6,199	6.7	8.6	10.6
Industrial (non-DS)	280,848	301.8	387.4	480.6
Aluminum Plant	160,600,000	172,567.1	221,538.6	274,831.2
Load 2				
Residential	1,113	1.7	2.2	2.7
Commercial	6,199	9.5	12.2	15.2
Industrial (non-DS)	280,848	431.1	553.4	686.6
Aluminum Plant	160,600,000	246,522.9	316,481.9	392,613.7
Load 3				
Residential	1,113	3.3	4.2	5.2
Commercial	6,199	18.3	23.4	29.1
Industrial (non-DS)	280,848	826.9	1,061.6	1,317.0
Aluminum Plant	160,600,000	472,880.0	607,075.1	753,111.0
Load 4				
Residential	1,113	4.1	5.3	6.5
Commercial	6,199	22.8	29.3	36.3
Industrial (non-DS)	280,848	1,032.6	1,325.6	1,644.5
Aluminum Plant	160,600,000	590,465.1	758,028.8	940,377.6

[1/]These estimates are based on a 6.875 discount rate, and a 90 percent hydropower cost allocation.
Source: DREW HIT, 1999 (Table 44).

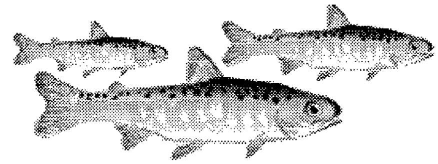
This analysis suggests that the average Pacific Northwest household monthly electricity bill could increase between $1.20 and $6.50 depending on which set of cost distribution and economic forecast assumptions is applied. The monthly bill increase for the average Pacific Northwest commercial establishment could range from $6.70 to $36.30.
The major impact would be to the industrial sector if the assumed cost distributions occur. For example, the average industrial customer (excluding the aluminum companies and other Direct Service Industries) could see monthly electricity bills increase between $302 and $1,645. The aluminum companies in the Pacific Northwest are extremely large consumers of electricity, with an average monthly consumption of 160,600,000 kWh. Any increase in the electricity rate will have a significant impact on their monthly power bills. Depending on the selection of cost distribution and economic condition impacts, the average monthly power bill for aluminum companies could increase between $172,600 and $940,400.

Monthly bill increases for selected business and public buildings are listed in Table 5.9-6. These potential increases are also included in the average totals listed in Table 5.9-5.

Table 5.9-6. Possible Monthly Bill Increases for Selected Commercial and Public Buildings under Alternative 4—Dam Breaching

Sector	Consumption (kWh/Month)	Monthly Bill Increase [1/] Low ($/month)	Medium ($/month)	High ($/month)
Load 1				
Grocery Store	120,000	128.9	165.5	205.4
Elementary School	27,000	29.0	37.2	46.2
Hospital	927,000	996.1	1,278.7	1,586.4
Hotel	400,000	429.8	551.8	684.5
Large Office Building	581,000	624.3	801.5	994.3
Load 2				
Grocery Store	120,000	184.2	236.5	293.4
Elementary School	27,000	41.4	53.2	66.0
Hospital	927,000	1,423.0	1,826.8	2,266.2
Hotel	400,000	614.0	788.2	977.9
Large Office Building	581,000	891.8	1,144.9	1,420.4
Load 3				
Grocery Store	120,000	353.3	453.6	562.7
Elementary School	27,000	79.5	102.1	126.6
Hospital	927,000	2,729.5	3,504.1	4,347.0
Hotel	400,000	1,177.8	1,512.0	1,875.7
Large Office Building	581,000	1,710.7	2,196.2	2,724.5
Load 4				
Grocery Store	120,000	441.2	566.4	702.6
Elementary School	27,000	99.3	127.4	158.1
Hospital	927,000	3,408.2	4,375.4	5,428.0
Hotel	400,000	1,470.6	1,888.0	2,342.2
Large Office Building	581,000	2136.1	2742.3	3402.0

[1/] These estimates are based on 1995 consumption data compiled by the NPPC, a 6.875 discount rate, and a 90 percent hydropower cost allocation.
Source: DREW HIT, 1999 (Table 45).



5.10 Agriculture, Municipal, and Industrial Water Uses

This section discusses the likely short-term and long-term impacts on agriculture, municipal, and industrial water uses associated with the four alternatives. Short-term effects are associated with construction- and demolition-related activities. Long-term effects are those that persist or occur after the dams have been breached and the river has returned to its natural level. In general, most of the discussion is focused on Alternative 4—Dam Breaching because little or no change in existing water use would be expected as the result of the first three alternatives. The information provided in this section is primarily derived from the Economic Analysis of Water Supply Effects (DREW Water Supply Workgroup, 1999). The report associated with this analysis is presented in its entirety as Section 3.4 of Technical Appendix I, Economics. See Table 5.10-1 for a summary of potential effects of the alternatives on water uses.

5.10.1 Agriculture Water Uses

5.10.1.1 Alternative 1—Existing Conditions

Under Alternative 1—Existing Conditions, the four hydropower facilities on the lower Snake River would continue to operate as originally designed. Pump stations for agriculture irrigation would continue to withdraw water from Ice Harbor Reservoir and pump the water to individual farm distribution systems. No impacts to agricultural water use are expected under this alternative.

Table 5.10-1. Summary of Potential Effects of the Alternatives on Agricultural, Municipal, and Industrial Water Uses

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Agricultural Water Uses	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• Pumping station intakes for irrigation that currently draw from Ice Harbor Reservoir would be above the water level. Pump modifications would be required for irrigation to continue. • Excess silt and sand could damage water supply system components.
Municipal, Industrial, and Other Uses	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• Pumping station intakes for M&I wells, privately owned wells, HMU irrigation systems, and cattle watering stations would need to be modified or the water supply would need to be replaced. • Excess silt and sand could damage water supply system components.

5.10.1.2 Alternative 2—Maximum Transport of Juvenile Salmon

Under this alternative, operation of the four hydropower facilities would continue as it would under Alternative 1—Existing Conditions. Therefore, no impacts to agricultural water use are expected under this alternative.

5.10.1.3 Alternative 3—Major System Improvements

Under this alternative, operation of the four hydropower facilities would continue as it would under Alternative 1—Existing Conditions. Therefore, no impacts to agricultural water use are expected under this alternative.

5.10.1.4 Alternative 4—Dam Breaching

Approximately 37,000 acres of irrigated farmland currently rely on pumped water from Ice Harbor Reservoir. Additional farmland is irrigated by private wells. Under Alternative 4—Dam Breaching, the river would return to its natural level and pumping station intakes that are currently in the reservoir would be above the water level. The long-term impacts to agricultural water users resulting from the elimination of the current water supply were assessed in terms of economic costs (DREW Water Supply Workgroup, 1999).

Economic Costs

The Corps evaluated two approaches to determine the economic effects of Alternative 4— Dam Breaching on Ice Harbor irrigators. The first approach—the system modification—estimated the costs to construct a new intake and distribution system that would be reliable at lower water levels. Irrigators would continue to produce crops under this approach. The second approach—farmland value— measured economic effects in terms of the change in farmland value if these lands no longer had access to irrigation water from the lower Snake River. Under this approach, the land currently irrigated would revert back to dryland farming. These two evaluation approaches are discussed in the following sections.

System Modification

This analysis approach identified and considered three significantly different options for the modification or replacement of river pump stations to maintain current water supply capability under Alternative 4—Dam Breaching (see Technical Appendix D, Natural River Drawdown Engineering for descriptions of all three options). An acceptable modified irrigation system would need to meet the following requirements: 1) the system would be operational prior to breaching of Ice Harbor Dam; 2) the system would function through a full range of river stages without interruption; and 3) the modified system would be able to handle a potentially large quantity of suspended sediment. Under current conditions, pump stations withdraw water from the Ice Harbor Reservoir and pump the water uphill several hundred feet to the individual farm distribution systems. Without the pool of water created by Ice Harbor Dam, the pumping station intakes would be completely out of water.

The first option involved modifying each existing pump station by extending pipes and installing additional or bigger pumps based on increases in lift requirements. During review of this concept, the engineering study team identified a number of technical concerns that indicated that this would not be a feasible option (see Technical Appendix D, Natural River Drawdown Engineering).

The second option involved the replacement of river stations with groundwater sources. Based on discussions with Dr. Robert Evans, an irrigation specialist in the County Extension office in Prosser, Washington, this does not appear to be a feasible option. Wells present numerous problems. There would likely be difficulties in receiving approval from the Washington State Department of Ecology (Ecology). These wells would need to be drilled deep and would, as result, have high initial and operating costs. The well water would also require treatment to counter high pH levels; and high sodium content in the well water could lead to soil sealing problems. There is also some concern that this system could not be installed without some interruption in irrigation water deliveries. Interruption of irrigation water deliveries would severely impact permanent crops, such as orchards and vineyards.

After consideration of options 1 and 2, the study team focused its efforts on a third option that they determined would technically work and satisfy the criteria outlined above. This option involves a pressure supply system that includes one large pumping station and distribution system with a sediment basin. The system would provide water via a single river pump station and the water would be delivered to

each farm through a main pipeline distribution system. Each farm-level pump would also require modifications in order to connect to the main pipeline distribution system. Because it is anticipated that sediment effects resulting from dam breaching would be significant, a sediment basin/reservoir is included as a component of the one large pump station system. The pump station would be located at a narrow point in the river to reduce problems with river fluctuation and meandering. For additional details on this option, refer to Technical Appendix D, Natural River Drawdown Engineering.

The primary irrigation system would consist of six main components: the pumping plant at the river, the pipe network, connections to existing irrigation systems, secondary pumping plants, a control system, and a sediment control reservoir. Total construction costs for this option were estimated to be $291,481,000 (1998 dollars) (see Table 5.10-2).

Table 5.10-2. Cost of Modifying Ice Harbor Agricultural Pumping Stations, 1998 Dollars

Component	Construction Costs
Mobilization, Demobilization, and Preparation.	$11,896,148
Earthwork for Structures	$5,207,616
Utilities	$6,997,734
Access Road	$4,849,592
Pipelines	$71,865,100
Pumping Plant	$9,243,520
Pumping Machinery	$52,678,290
Subtotal, Pump Plant System	***$162,738,000***
Subtotal, Sediment Reservoir	***$128,743,000***
Pump Plant and Reservoir Total	**$291,481,000**

Source: DREW Water Supply Workgroup, 1999 (Table 3.4-5, Technical Appendix I, Economics)

The modified agricultural pump system would likely result in increased energy and other operation and maintenance expenses as well. Additional lift of the irrigation water with new pumps or the conversion of existing pumps would result in higher operating costs. Specifically, the greater horsepower would increase the cost of power to the water user. Added equipment could also require greater maintenance expenditures and could increase future replacement costs.

Increased maintenance necessary to treat sediment-related problems, even with a sediment control reservoir in place, is not easily predictable. Replacement of worn parts of pumps, valves, sprinklers, and filters could initially be significant.

Although the extent of increased operation and maintenance (O&M) expenses associated with the modified irrigation system is not fully understood, additional O&M expenses associated with modifying the existing pump stations are estimated to

be $3,573,000 per year (1998 dollars). The estimated modification and O&M costs provide an upper bound measurement of the economic effects to irrigators.

Farmland Value

This analysis based the determination of economic effects to irrigators under Alternative 4—Dam Breaching on a change in farmland values that would occur with elimination of the current water supply. Typical land values for farm properties near Ice Harbor were used. This information was compiled through discussions with farm managers, cooperative extension agents, farmland appraisers, agricultural economics professors, and the use of published enterprise budget sheets for a number of crops. Analysis of this data provides an estimate of typical farmland value and permits the quantification of the economic effect to farmland owners under Alternative 4—Dam Breaching.

Table 5.10-3 summarizes the estimated market value of the primary types of irrigated farmland in the region. In addition, local farm appraisers and agricultural experts have indicated that non-irrigated farmland near Ice Harbor is limited to some grazing a short period of the year and would sell for $75 to $150 per acre.

Table 5.10-3. Farmland Value Estimates for Selected Crops

Type of Cropland	Value per Acre
Row Crops	$2,500 to $3,500
Vineyards (at maturity)	$5,500 to $9,500
Apple Orchards (at maturity)	$10,000 to $32,000
Poplars	$2,500 to $3,500
Non-irrigated Farmland	$75 to $150

Source: DREW Water Supply Workgroup, 1999 (Table 3.4-6, Technical Appendix I, Economics)

Approximately 37,000 acres of irrigated farmland currently rely on pumped water from Ice Harbor. Of this amount, it is estimated that more traditional irrigated cropland accounts for 28,400 acres and that the remaining 8,600 acres are poplar plantations. Detailed crop information for about 20,000 of the irrigated acres at Ice Harbor was collected through interviews with farm operators. The crop information in conjunction with the farmland value data described above was used to determine the average per acre value of irrigated farmland in the region. Based on the farmland value approach, the average per acre value of irrigated farmland equals $4,100.

The economic impact to pump irrigators under Alternative 4—Dam Breaching was estimated by applying this average per acre value to the total amount of irrigated crop acreage, adding the value of the poplar tree acreage, and then subtracting the value of non-irrigated cropland (Table 5.10-4). The economic effect of Alternative 4—Dam Breaching measured on the basis of a change in farmland value is equal to $134,240,000.

Table 5.10-4. Economic Impact to Pump Irrigators based on Change in Farmland Values under Alternative 4—Dam Breaching

	Value/Acre	Number of Acres	Total Value
Irrigated Cropland	$4,100	28,400	$116,440,000
Poplar Trees	$2,500	8,600	$21,500,000
Total Value of Irrigated Cropland			$137,940,000
Non-Irrigated Cropland	$100	37,000	$3,700,000
Total Change in Value			**$134,240,000**

Source: DREW Water Supply Workgroup, 1999 (Section 3.4.2.4, Technical Appendix I, Economics)

Summary

The economic analyses conducted by the DREW Water Supply Workgroup indicate that the cost of modifying the Ice Harbor agricultural pumping stations to provide current water supplies following dam breaching ($291,481,000) would be more than twice the value of the 37,000 acres of farmland that are irrigated by Ice Harbor ($137,940,000). Given the extensive investment that would be required to maintain existing levels of water supply following drawdown, relative to land values, production would be unlikely to continue on lands that are currently irrigated with water from Ice Harbor. A much reduced irrigation system would be more appropriate. Design and cost data for a reduced system are not available. Therefore, the water supply economic analysis used the farmland value method to assess the economic effects of dam breaching (see Technical Appendix I, Economics). In the absence of Congressional funding to modify existing pumps, it seems likely that Ice Harbor irrigators going out of business would be an unavoidable adverse impact.

Sediment Concerns

During and after implementation of Alternative 4—Dam Breaching, it is likely that the silt and sand that has accumulated in the reservoirs behind the four lower Snake River dams would be eroded and entrained by the faster moving river flows. It could take several years for this material to be depleted. Excessive quantities of silt and sand could cause damage to pumps, valves, and other components of water supply systems. Intakes would have to be kept clean and clear. Sand particles are heavy enough that most could be kept out of well-designed pumping systems. The silt, however, could remain suspended for long periods of time. The most practical means of handling sand and silt would be to use large settling ponds. No data is available to quantify the expected sediment load in the river, therefore the extent of required settling facilities is unknown at this time.

Water intakes in the Columbia River could also be susceptible to short-term impacts. The majority of the sediments carried downstream during and following dam breaching would be deposited in the upper end of the McNary pool. To avoid problems due to potential sedimentation under Alternative 4—Dam Breaching, water intakes in the pool should be located as far above the streambed as practical and should be located in areas having noticeable flow velocities high enough to

discourage the deposition of sediment. Locating water intakes in relatively calm water is not advisable where there is a potential for higher rates of sediment deposition (Technical Appendix F, Hydrology/Hydraulics and Sedimentation).

5.10.2 Municipal, Industrial, and Other Uses

5.10.2.1 Alternative 1—Existing Conditions

Under Alternative 1—Existing Conditions, the four hydropower facilities on the lower Snake River would continue to operate as originally designed. No impacts to municipal and industrial (M&I) water users are expected under this alternative.

5.10.2.2 Alternative 2—Maximum Transport of Juvenile Salmon

Under this alternative, operation of the four dams would continue as it would under Alternative 1—Existing Conditions. Therefore, no impacts to M&I water users are expected under Alternative 2—Maximum Transport of Juvenile Salmon.

5.10.2.3 Alternative 3—Major System Improvements

Under this alternative, operation of the four hydropower facilities would continue as it would under Alternative 1—Existing Conditions. Therefore, no impacts to M&I water users are expected under Alternative 3—Major System Improvements.

5.10.2.4 Alternative 4—Dam Breaching

Municipal and Industrial Water Uses

The M&I pump stations that draw from the lower Snake River are all located on Lower Granite Reservoir. Uses include municipal water system backup, golf course irrigation, industrial process water for paper production, and concrete aggregate washing. Under Alternative 4—Dam Breaching, the river would return to its natural level and pumping stations would require modifications to maintain current water supplies. The assessment of long-term economic effects on M&I water users is based on the required system modification costs. Modifications required for the M&I pump stations at Lower Granite are summarized in Table 5.10-5.

The total modification costs for these M&I pump stations at Lower Granite would range from $11,514,000 to $55,214,000. There is a cost range because the required modification costs for Potlatch Corporation very significantly depending on whether a water cooling facility would be necessary. The Potlatch Corporation system modifications would be either $10.8 million or $54.5 million of the total.

Privately Owned Wells

Review of Ecology water well reports identified 209 functioning wells within approximately one mile of the lower Snake River. The Corps determined one mile to be the range within which wells could be potentially affected under Alternative 4—Dam Breaching. Based on an analysis conducted by engineers from the Corps, about

Table 5.10-5. Modifications Required for M&I Pump Stations at Lower Granite

Pump Station	Summary of Modifications
Clarkston Golf Course	Would require modifications including construction of a utility building, water intake system, and power supply.
Potlatch Corporation	Would require extensive modifications including the primary plant intake, the plant diffuser, and potentially a water cooling facility.
Atlas Sand & Rock	Would require modifications including construction of a utility building, water intake system, and power supply.
Lewiston Golf Club	Would require modifications including construction of a utility building, water intake system, and power supply.
Two PUD Stations	Have not been used in several years and would not be modified.

Source: DREW Water Supply Workgroup, 1999 (Section 3.4.3.2, Technical Appendix I, Economics)

40 percent or 95 of these wells are expected to require modification if dam breaching were to occur. Total well modification costs are presented by reservoir in Table 5.10-6. Total costs are approximately $56,447,000. This total includes direct, contingency, project management, and overhead costs.

Table 5.10-6. Well Modification Costs by Pool, 1998 Dollars

Pool	Well Modification Cost
Ice Harbor	$ 18,373,000
Lower Monumental	$ 12,462,000
Little Goose	$ 7,797,000
Lower Granite	$ 17,815,000
Total	**$ 56,447,000**

Source: DREW Water Supply Workgroup, 1999 (Table 3.4-14, Technical Appendix I – Economics)

The cost estimate was based on a typical cost per well with average increases in pump size and well depth. The estimate does not include additional operation and maintenance expenses associated with the well modifications. As a practical matter, each well would have to be considered individually under dam breaching conditions. Conditions after dam breaching would have to be observed to determine exactly how deep a well would have to be drilled to produce water at current rates. The Corps recommends that all well modifications be performed after dam breaching has occurred. It is unclear what the water well users would do in the interim.

Habitat Management Units

Ten Habitat Management Units (HMUs) have irrigation systems that are either supplied by surface water intakes in the river or by groundwater wells. Under Alternative 4—Dam Breaching, each pumping station would have to be modified to

accommodate the lower and more fluctuating water surface levels. Installation of new piping and increased pump requirements could not be done prior to dam breaching, therefore temporary measures would be implemented for the irrigation period of August 1 to approximately early October. Temporary measures would include use of trailer-mounted pumps and flexible piping. The two water wells would not be modified until after the dams were breached and the groundwater was stabilized.

Cattle Watering

Many of the land acquisition agreements for the lower Snake River reservoirs provide landowners with guaranteed river access for cattle watering. Under Alternative 4—Dam Breaching, it would not be practical to provide access to the river for cattle watering. Environmental concerns about cattle waste in the river and the need to extend fences out into the river make providing river access impractical. To meet the legal obligation to provide for cattle watering under this alternative, a well would have to be drilled and a pump and water tank installed at each of the watering sites. Since the wells could not be drilled until after the dams were breached, temporary watering facilities would be provided and maintained until the permanent system was complete. Temporary watering would be truck-hauled water to each watering site (see Annex L of Technical Appendix D, Natural River Drawdown Engineering for the Cattle Watering Facilities Monitoring Plan).

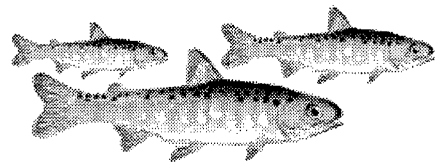
5.10.2.5 Summary of Economic Effects

The economic effects of Alternative 4 —Dam Breaching were evaluated for three types of water use: agricultural uses, M&I uses, and private wells. Total direct economic effects were estimated to range from $202.2 million to $245.9 million. Average annual costs were calculated on a 100-year period of analysis at three discount rates—6.875 percent, 4.75 percent, and 0.0 percent (Table 5.10-7). Average annual costs range from $2.2 million using a 0.0 percent discount rate to $15.4 million using a 6.875 percent rate.

Table 5.10-7. Average Annual Economic Effects by Discount Rate (000s of dollars)

	6.875 % Discount Rate		4.75 % Discount Rate		0.0 % Discount Rate	
Alternative 4—Dam Breaching	**Minimum**	**Maximum**	**Minimum**	**Maximum**	**Minimum**	**Maximum**
Loss of Irrigated Farmland Value		(9,241)		(6,438)		(1,342)
M&I Pump Stations[1/]	(793)	(3,801)	(552)	(2,648)	(115)	(552)
Privately Owned Wells		(3,886)		(2,707)		(565)
Total Costs	(13,920)	(16,928)	(9,697)	(11,793)	(2,022)	(2,459)
Total Cost Point Estimate	(15,424)		(10,745)		(2,241)	

1/ A range of costs is presented for M&I pump stations because the modification costs for the Potlatch Corporation's Lewiston, Idaho facility vary significantly depending on whether a water cooling facility would be necessary.
Source: DREW Water Supply Workgroup, 1999 (Table 3.14-16, Technical Appendix I, Economics)



5.11 Land Ownership and Use

Table 5.11-1 summarizes the potential effects of the alternatives on land ownership and use.

5.11.1 Regional Land Use

Land use in much of the 25 county study area is predominantly agricultural (see Figure 4.11-1) and it is this component of regional land use that would most likely to be affected by the proposed alternatives. It is not likely that regional range land, forest land, or urban areas would be significantly affected. As a result, the following discussion focuses on agricultural land use.

5.11.1.1 Alternatives 1 Through 3

Agricultural land would not be affected by the first three alternatives considered under this FR/EIS.

5.11.1.2 Alternative 4—Dam Breaching

Agricultural land use would be affected by changes in transportation and water supply associated with Alternative 4—Dam Breaching. The following sections discuss these changes in turn.

Transportation

Transportation changes associated with the Alternative 4—Dam Breaching, could significantly affect regional farmers. Approximately 5,000 farms are located in 13 of the 25 counties in the lower Snake River study area. These 13 counties, which currently account for approximately 75 percent of total grain movements on the lower

Table 5.11-1. Summary of Potential Effects of the Alternatives on Land Ownership and Use

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Regional Land Use	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• Transportation cost increases could reduce or eliminate production on some farm lands. • Reduced access to irrigation water supplies could reduce or eliminate production on some farm lands.
Lower Snake River Corridor	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• Project lands would not be needed for commercial navigation or hydropower. • Project lands currently leased to state and local governments and private entities for fish and wildlife management would likely continue to be leased. • Public control of a significant portion of public lands would likely be necessary to protect salmon and their habitat. • Restoration of previously submerged lands would be likely.

Snake River, would experience 74 percent of the total increase in transportation costs associated with dam breaching.

The five counties that ship the largest quantities of grain on the lower Snake River would be the most affected by the increased costs. Latah, Idaho, and Lewis counties in Idaho, and Whitman and Walla Walla counties in Washington would see over 60 percent of the total cost increase. Whitman County, which, alone, accounts for 33 percent of the total grain shipped on the lower Snake River, would incur about 35 percent of the total increased cost. Estimated cost increases per bushel currently shipped on the lower Snake River range from $0.06 per bushel in Wallowa County, Oregon to $0.53 per bushel in Idaho County, Idaho (DREW Social Analysis Workgroup, 1999).

A range of potential cost increases per acre are presented by county in Table 5.11-2. These costs represent three scenarios. The first scenario assumes that cost increases would only be distributed across the acres that produce crops that are shipped via the lower Snake River. The second scenario assumes that the costs would be distributed across all the acres that produce wheat and barley in each county. The third scenario distributes costs across all cultivated acres in each county.

Table 5.11-2. Increased Transportation Costs and Total Costs per Acre by County under Alternative 4

County	Avg. Impact per Acre for Bushels Shipped on LSR ($)[1/]	Avg. Total Impact per Acre of Total Wheat and Barley Production ($)[2/]	Avg. Total Impact per Acre of Total Harvested Cropland ($)[3/]
Upriver			
Latah, ID	24.66	19.21	9.47
Lewis, ID	15.46	19.97	8.20
Idaho, ID	37.20	36.58	17.11
Nez Perce, ID	33.00	10.23	7.11
Clearwater, ID	31.09	8.01	1.91
Wallowa, OR	4.07	1.68	0.86
Reservoir			
Whitman, WA	21.60	12.40	11.15
Walla Walla, WA	12.66	4.09	3.90
Adams, WA	3.65	1.49	1.33
Columbia, WA	9.52	4.80	5.62
Garfield, WA	10.46	4.25	5.47
Asotin, WA	27.86	13.62	11.87
Downriver			
Franklin, WA	7.43	0.65	0.42

[1/] Average impact per acre for bushels shipped on the lower Snake River = total cost increase per county/total number of bushels from that county shipped on the lower Snake River * average yield of bushels per acre.

[2/] Average total impact per acre of total wheat and barley production = total cost increase per county/total number of bushels produced in that county * average yield of bushels per acre.

[3/] Average total impact per acre of total harvested cropland = total cost increase per county/total number of harvested acres in that county.

Note: All costs per bushel include transportation, handling, and storage costs.

LSR – lower Snake River

Source: DREW Social Analysis Workgroup, 1999

Cost increases per acre under the first scenario range from $3.65 per acre in Adams County, Washington to $37.20 per acre in Idaho County, Idaho. The first scenario represents a worst case situation that assumes that all of a farmer's production is shipped via the lower Snake River. This is likely the case for those farms located close to the river. The other two scenarios assume that not all of a farmer's production is shipped via the river and that per bushel cost increases would be distributed over a larger number of acres. The effects on individual farms measured on a per acre basis would likely fall within the ranges presented under the three scenarios depending on the percentage of production that currently moves on the lower Snake River, total acreage planted in wheat and barley, and the availability of transportation alternatives.

Farms in specific counties could see annual impacts as high as $8,935, while other counties could see impacts lower than $1,000 per farm (Table 5.11-3). These increases could result in marginal farms going out of business, at least in the short run. In the long-term it is likely that these increased costs would be capitalized into

the value of the land. The value of the land would be reduced and agricultural production would continue. Alternatively, these increased costs could accelerate the existing trend toward consolidation that is evident in all three subregions (see Figures 4.14-6 through 4.14-8).

Table 5.11-3. Average Increased Transportation Cost per Farm by County under Alternative 4—Dam Breaching

County	Number of Farms (1992)	Avg. Trans Cost per Number of Farms ($)[1/]	Average Total Cost per Total Number of Farms ($)[2/]
Upriver			
Latah, ID	492	2,085	3,848
Lewis, ID	143	6,027	7,092
Idaho, ID	495	1,971	4,793
Nez Perce, ID	249	2,809	4,717
Clearwater, ID	139	171	332
Wallowa, OR	267	173	173
Reservoir			
Whitman, WA	1,001	5,722	8,935
Walla Walla, WA	594	626	2,200
Adams, WA	505	785	1,021
Columbia, WA	157	1,747	3,432
Garfield, WA	163	3,617	3,617
Asotin, WA	66	3,266	5,501
Downriver			
Franklin, WA	732	50	167

[1/] Transportation cost increase per county divided by number of farms per county.
[2/] Transportation, storage, and handling increases per county divided by number of farms per county
Source: DREW Social Analysis Workgroup, 1999

Water Supply

Approximately 37,000 acres of cropland are presently irrigated from Ice Harbor reservoir (see Figure 4.11-1). The Corps used two approaches to estimate the economic effects of Alternative 4 on Ice Harbor irrigators. These approaches—the pump modification approach and the farmland value approach—and the associated projected costs are discussed in Section 5.10.1.4. Both approaches indicate that the cost of modification would be very high and, in the absence of Congressional appropriation, costs to modify the pumps could be prohibitive based on total farm values. Under these circumstances, production would be unlikely to continue on these lands.

5.11.2 Lower Snake River Corridor

5.11.2.1 Alternatives 1 Through 3

Land ownership and use would remain essentially unchanged under the first three alternatives considered in this FR/EIS. The four lower Snake River dams and

existing recreation areas and habitat management units (HMUs) would remain in place.

5.11.2.2 Alternative 4—Dam Breaching

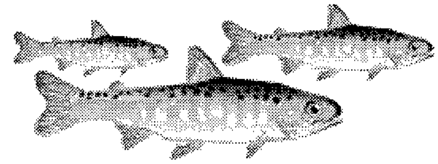
Under Alternative 4—Dam Breaching, an estimated 13,771.6 acres of currently inundated land that lie between the ordinary high water line of the original river bed and the normal operating pools would be exposed (Technical Appendix K, Real Estate). The state-owned riverbed, which comprises 19,464 acres, was not acquired by the Federal government. Total acres and acres below normal operating pool are presented by dam in Table 5.11-4. The aesthetic effects of this alternative are discussed in Section 5.14.

Table 5.11-4. Project Lands

	Total Acres	Acres Below Normal Operating Pool
Lower Granite	668.6	8,448.2
Little Goose	15,684.8	10,825.2
Lower Monumental	14,104.0	4,960.4
Ice Harbor	13,039.5	9,001.8
Total[1/]	**60,496.9**	**33,235.6**

[1/] The acreage of currently inundated land lying between the ordinary high water line of the river bed and the normal operating pools (13,771.6 acres) is calculated by subtracting the area of the state-own riverbed (19,464 acres) from the total acreage below normal operating pool (33,235.6 acres).
Source: Technical Appendix K, Real Estate.

Under Alternative 4—Dam Breaching, project lands would be retained to monitor and maintain the biological effectiveness of dam breaching. Although project lands would no longer be required for commercial navigation or hydropower, a significant portion would arguably be needed to meet other existing or newly authorized purposes. Significant acreage is, for example, leased to state and local governments and private entities for recreation or fish and wildlife management. It is expected that many of these lessees would choose to continue their operations under the same or modified arrangements. It is also anticipated that public control of a significant portion of public lands would be necessary to protect the environmental and natural benefits to salmon associated with dam breaching. Restoration of previously submerged lands is also likely. It is expected that any reauthorizing legislation would include provisions to meet the above concerns. If any lands were no longer required, they would be reported to the General Services Administration (GSA) for disposal. GSA would screen the lands with other Federal agencies to determine whether there is another Federal requirement for the property. If not, GSA would then dispose of the lands to other eligible public or private entities or individuals.



5.12 Recreation and Tourism

Three of the alternatives being evaluated in this FR/EIS would have essentially the same effect on recreation and tourism at the four lower Snake River hydropower facilities (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor). Implementing Alternatives 2 and 3 would not lead to any changes to existing recreation facilities or usage patterns. From a recreation use perspective they would essentially be the same as Alternative 1—Existing Conditions. Alternative 4—Dam Breaching, would have significant effects on recreation and tourism. Alternative 4—Dam Breaching would influence recreation by affecting the ability to use existing developed and dispersed recreation areas and changing the type of recreational activities that could occur in the study area. Table 5.12-1 summarizes the potential effects of the alternatives on recreation.

This section begins with an examination of the effects of each alternative on existing recreation areas and facilities. It then discusses the likely effects each alternative would have on recreational activities, use patterns, and visitation.

5.12.1 Alternative 1—Existing Conditions

Alternative 1—Existing Conditions would maintain existing operations and would not introduce or require changes to recreation areas at Lower Grantie, Little Goose, Lower Monumental, or Ice Harbor dams.

Table 5.12-1. Summary of Potential Effects of the Alternatives on Recreation

Impact Areas	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Developed Recreation Areas and Dispersed Recreation Sites	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• Eleven of the 33 developed recreation areas would be closed and 18 would require extensive modifications. • Fish viewing facilities would no longer be functional. • Many current dispersed sites dependent on current aesthetic features or on water access would no longer be used. • New dispersed sites would develop in the future as the river shoreline stabilized and beaches and views developed.
Effects on Recreational Activities and Visitation	Current usage patterns would generally continue, although the demand for recreation opportunities will increase as the regional population grows.	Possible improvement in fishing-related opportunities and use of facilities if fish population levels increase.	Same as Alternative 2.	• Water-based recreation activities would change from flat-water to river-oriented and there would be an accompanying shift in usage patterns. This shift would take a number of years. • Moving or redesigning existing facilities, building new facilities, and revegetation efforts would allow for quicker recovery of land-based activities. • Fishing activity in the first years following breaching would be lower, but would rebound and be enhanced as salmon recovered and resident species stabilized. There would be a shift in the type of fishing/fish available. • Overall, both recreation fishing and general recreation would be expected to increase within 10 years as the river is restored and if fish respond to natural river conditions.

5.12.1.1 Effects on Recreational Facilities and Dispersed Use Areas

Under Alternative 1—Existing Conditions, recreational facilities would continue to be as accessible and useable as they currently are. Over time, it is likely that existing facilities would be upgraded and new facilities added as budgets and demands warrant.

5.12.1.2 Effects on Recreational Activities and Visitation

As the regional population grows, it can be assumed that the demand for land- and water-based recreation opportunities will increase. Although unforeseen events such as increases in petroleum prices, regulatory events, or changes in the popularity of recreational activities could change the nature of recreational use of the lower Snake River facilities, recreational use of the lower Snake River can be expected to increase as the demand for flatwater- and shoreline-based recreational activities increase. At the same time that the demand for flatwater recreation is increasing, the demand for resources for recreation that occurs on free-flowing rivers is also increasing.

Under Alternative 1—Existing Conditions, the lower Snake River facilities would help meet the demands for flatwater recreation, but would not help meet the demands for free-flowing river recreation. Also, recreational activities that are not directly dependent upon river flow configurations such as picnicking, camping, and hiking would continue to be accommodated.

5.12.2 Alternative 2— Maximum Transport of Juvenile Salmon

The operational changes that would occur with Alternative 2—Maximum Transport of Juvenile Salmon would have no influence on recreational facilities. Based on analysis presented by NMFS, this alternative would likely have very little effect on the numbers of salmon or steelhead available for recreational harvest (see Technical Appendix A, Anadromous Fish). However, if salmon survival estimates improve and fish population levels increase, more recreational harvest may be possible and usage could increase.

5.12.3 Alternative 3—Major System Improvements

As with Alternative 2—Maximum Transport of Juvenile Salmon, the operational changes that would occur with Alternative 3—Major System Improvements would have no influence on recreational facilities. Based on analysis presented by NMFS, this alternative would likely have very little effect on the number of salmon or steelhead available for recreational harvest. However, if salmon survival estimates improve and fish population levels increase, more recreational harvest may be possible and usage could increase.

5.12.4 Alternative 4—Dam Breaching

Breaching the four lower Snake River dams would have dramatic regional effects on recreation. The regional (eastern Washington, northeastern Oregon, and western central Idaho) supply of lakes that could support flatwater recreation would be reduced by 34,000 acres with the breaching of the dams. This would have direct and indirect effects on recreation because many current users would be displaced to other lakes. Some activities that occur on lakes—such as certain types of boating, fishing, and wildlife viewing—could also occur on a free-flowing river. Other activities that require or favor flatwater conditions—such as mooring boats, water skiing, and excursion cruise ships—would be negatively affected by dam breaching or would not be able to take place all.

Breaching the dams would expand opportunities for those recreational and tourism activities that require or prefer free-flowing rivers. By breaching the dams, a 140-mile-long free-flowing stretch of one of the major river systems in the West would be made available to recreationists.

The following sections describe the effects of breaching on project recreation facilities and visitation.

5.12.4.1 Effects on Developed Recreation Facilities

Alternative 4—Dam Breaching would have significant effects on the usability of existing recreation areas that are adjacent to the four lower Snake River dams and reservoirs. Most of the existing recreation facilities were developed around the existing reservoirs and a flatwater environment. Because existing water-based recreation facilities such as boat ramps, swimming beaches, and moorage facilities were designed to operate within very specific ranges of elevations (generally within 5 feet of full pool), none of these facilities could continue to be used without modification.

Some recreation facilities such as boat ramps would be able to be extended under the Corps configuration and still provide access to water. Other features such as parking areas and lawns could be recreated closer to the river to provide access. Some facilities however, such as marinas and moorage facilities, would likely not be rebuilt due to the incompatibility of these facilities with a free-flowing, river. Prior to the construction of Lower Granite Dam, there were limited moorage facilities available along the lower Snake River. If moorage facilities were rebuilt, the capacity would be much less than that which exists now.

Under Alternative 4—Dam Breaching, the Corps estimates that 11 of the 33 developed recreation areas would be closed and 18 would require extensive modifications if they were to be retained (Table 5.12-2). Eleven recreation areas would be closed because they would no longer be able to provide access to water and there are no other attributes that would be important enough to keep them open for recreationists. The water access facilities that would be affected at these sites would include boat ramps, marinas, moorage facilities, and developed swimming areas. Little Goose would be most affected, with four (out of a total of six) recreation areas being closed. Lower Monumental would have three recreation areas closed (out of a total of six), as would Lower Granite (out of a total of 14). Ice Harbor would be the least affected with one area out of six closed.

Eighteen of the recreation areas would be modified to offer water access for boats. River access for boats at these 18 recreation areas would be provided by ramps, which would either be extensions of existing ramps or new ramps. None of the marina and/or boat moorage and/or boat basin and/or dockside service facilities (i.e., marine fuel and dumping facilities) that are located at 10 recreation areas scattered along the four lower Snake River facilities would be able to operate under Alternative 4—Dam Breaching. Prior to the construction of Lower Granite, there were several boat moorage facilities along the Snake River in the Lewiston-Clarkston area (Corps, 1975). It might be possible to develop small boat basins for temporary moorage along the river, although this type of development would have to be designed to be compatible with salmon recovery plans.

Alternative 4—Dam Breaching would also have impacts on upland recreation facilities that although not dependant upon water, are enhanced by the proximity of water. Many of the recreation areas have facilities such as picnic shelters, concrete walks, and interpretive signs that are located near the existing lakes. Although the activities that occur at these facilities are not water dependant, the proximity of water enhances the recreation experience. Some of these facilities such as picnic tables could be rather easily moved closer to the river's edge to provide proximity to water. However, other more permanent facilities such as shade structures and parking areas may not be able to be relocated because of the need to allow natural riparian functions to develop along the newly exposed river shorelines.

Table 5.12-2. Differences Between Existing Lake Level Ranges and Alternative 4 River Elevations (in feet) at Developed Recreation Areas

Recreation Area	Current Lake Elevation	Old River Elevation	Difference (feet)
Lower Granite (Lower Granite Lake)			
Hells Gate State Park	733-738	725	(8-13)
Chief Looking Glass Park	733-738	725	(8-13)
Clearwater Ramp	733-738	720	(13-18)
Swallows Park	733-738	715	(18-23)
Southway Ramp	733-738	715	(18-23)
Hells Canyon Resort	733-738	705	(28-33)
Greenbelt Ramp	733-738	705	(28-33)
Chief Timothy State Park	733-738	685	(48-53)
Nisqually John Ramp	733-738	685	(78-83)
Blyton Landing	733-738	645	(88-93)
Wawawai Co. Park	733-738	635	(98-103)
Wawawai Landing	733-738	635	(98-103)
Offield Landing	733-738	625	(108-113)
Little Goose (Lake Bryan)			
Illia Dunes	633-638	615	(18-23)
Boyer Park and Marina	633-638	615	(18-23)
Illia Landing	633-638	615	(18-23)
Willow Landing	633-638	575	(58-63)
Garfield County Ramp	633-638	555	(78-83)
Central Ferry State Park	633-638	545	(88-93)
Little Goose Landing	633-638	525	(108-113)
Lower Monumental (Lake West)			
Riparia	537-540	515	(22-25)
Texas Rapids	537-540	505	(32-35)
Lyons Ferry State Park	537-540	475	(62-65)
Lyons Ferry Marina	537-540	475	(62-65)
Ayer Boat Basin	537-540	445	(92-99)
Devil's Bench	537-540	435	(102-105)
Ice Harbor (Lake Sacajawea)			
Windust Park	437-440	425	(12-15)
Fishhook Park	437-440	365	(72-75)
Levey Park	437-430	345	(92-95)
Charbonneau Park	437-430	345	(92-95)
North Shore Ramp	437-430	345	(92-95)

Alternative 4—Dam Breaching would preclude the two cruise lines that currently take tourists through the Snake River facilities from operating their cruise ships along the lower Snake River. The two companies take approximately 5,000 tourists a year as far as Clarkston. From Clarkston, many tourists take jetboat rides up the Snake River into Hells Canyon. Along the route, many of the cruise tourists along with others, spend time at the four lower Snake River dams watching salmon pass through the fish ladders.

Under Alternative 4—Dam Breaching, the fish viewing facilities would no longer be functional and, due to the free-flowing nature of the river, would not be reconstructed. Fish viewing opportunities could occur at hatcheries or would consist of viewing fish from above at outdoor interpretive displays.

The following is a discussion on the effect of Alternative 4—Dam Breaching on recreation areas at the four Lower Snake River dams.

Lower Granite (Lower Granite Lake)

Eight of the 14 existing Lower Granite recreation areas that provide boating access to water could continue to function with site modifications. Three primitive and remote developed recreation areas that currently provide boating access (Offield Landing, Blyton Landing, and Nisqually John Landing) would be closed due to the inability to access the river from the sites. One recreation area (Chief Looking Glass Park) that currently provides water access would remain open but would no longer be able to provide access to water. The four recreation areas that currently provide marina or moorage facilities (Hells Canyon Resort, Greenbelt Ramp and Boat Basin, and Hells Gate State Park) would no longer be useable under this alternative. It would however, be possible to extend boat ramps at Hells Canyon State Park, Hells Canyon Resort, and the Greenbelt Ramp to provide access to the river. Whether the lessors of the Hells Canyon Resort would choose to extend their boat ramp and keep other facilities open is not known.

Because the river elevation would be between 8 feet (Hells Gate State Park and Chief Looking Glass Park) and 53 feet (Chief Timothy State Park) below existing lake levels, none of the existing Lower Granite developed swimming areas would be usable. Undeveloped natural beaches may become established at or near these sites, but due to the free-flowing nature of the restored river, it is not likely that developed swimming facilities would be reestablished.

Upland facilities at the Lower Granite recreation areas would also be affected by breaching Lower Granite Dam. Not only would these areas be higher than the river, they would also be farther from the river than under existing conditions. As the dewatered areas stabilize and become revegetated, views of the river from these recreation areas may be blocked unless view corridors are maintained.

The breaching of Lower Granite Dam would result in the elimination of the dam as a bridge for County Road 94 (Almota Ferry Road). By eliminating vehicular access to the dam, recreationists from towns south of the river such as Pomerory, Lewiston, and Clarkston would have to drive farther to reach the north side of the river. Likewise, recreationists from towns north of the river such as Pullman and Colfax would have to drive farther to get to the south side of the river. Under Alternative 4—Dam Breaching, recreationists would either cross downriver at the Central Ferry Bridge (which is 24 river miles down river from the dam) or upriver at Clarkston (which is 32 river miles upriver from the dam).

The following is a brief description of the effects that Alternative 4—Dam Breaching would have on the individual recreation areas at Lower Granite. The projections set forth regarding closures and modifications of Corps facilities are contingent on future physical conditions, funding limits, and authorities.

Hells Gate State Park

The river would be between 8 and 13 feet below the existing pool elevation ranges. As a result, the six-lane boat ramp, handling docks, marine, marine fuel, marine dump station, and irrigation intakes could not be used. The boat ramp would not be extended to provide river access.

Chief Looking Glass Park

Alternative 4—Dam Breaching would result in the river being between 8 and 13 feet below existing pool elevation ranges. At the new elevation, the boat basin, two-lane boat ramp, and handling dock would not be functional and would be taken out of service.

Clearwater Ramp

As a result of Alternative 4—Dam Breaching, the river would be between 13 and 18 feet below the current pool elevation ranges. The two-lane boat ramp and handling docks would not be functional under Alternative 4—Dam Breaching, but the boat ramp would be extended.

Swallows Park

The river would be between 18 and 23 feet below the existing pool elevation ranges. As a result, the four-lane boat ramp, handling dock, and swimming area would be unusable and access between the waterside day-use areas would be difficult. The irrigation system would be affected. Some of these impacts could be mitigated, including the boat ramp which would be extended to provide river access.

Southway Ramp

Alternative 4—Dam Breaching would result in a river elevation that would be between 18 and 23 feet lower than the current pool elevation ranges. As a result, the two-lane boat ramp and handling dock would be extended.

Hells Canyon Resort

The river would be between 28 and 33 feet below the existing pool elevation ranges. As a result, the marina, two-lane boat ramp, and all facilities would not be usable and irrigation intakes would be affected. The boat ramp could be extended. It is not known if the lessors of the resort would choose to extend the ramp or attempt to keep other facilities open.

Greenbelt Ramp

With the river between 28 and 33 feet below current pool elevations, the two-lane boat basin, boat ramp, and handling docks would not be functional. The boat ramp would be modified to provide river access.

Chief Timothy State Park

The river would be between 48 and 53 feet below the current pool elevation ranges, which would render the four-lane boat ramp, handling docks, swimming beach and irrigation system unusable. The boat ramp would be modified to provide river access.

Nisqually John Ramp

Under Alternative 4—Dam Breaching, the river would be between 78 and 83 feet below the current pool elevation ranges. As a result, the one-lane boat ramp and primitive swimming would not be functional and the area would be closed.

Blyton Landing

The river would be between 88 and 93 feet lower than the existing pool elevation which would eliminate use of the one-lane boat ramp. The area would be closed.

Wawawai County Park

With the river between 98 to 103 feet below the existing pool elevation ranges, the embayment that provides water access to the park would be dry and irrigation intakes would not work. As a result, the park would have no access to the river and would be separated from the river by the railroad line. The boat ramp would not be serviceable.

Wawawai Landing

Under Alternative 4—Dam Breaching, the river would be from 98 to 103 feet below the existing pool elevation ranges. The boat basin, boat ramp, primitive swimming beach, and Washington State University docks would not be usable. Some mitigation measures would allow limited use of some recreation facilities, including the boat ramp which would be modified.

Offield Landing

The river would be from 108 to 113 feet lower than the existing pool elevation ranges. The one-lane boat ramp and handling docks would not function and the area would be closed.

Little Goose (Lake Bryan)

Facilities at two (Boyer Park and Central Ferry State Park) of the six Little Goose recreation areas could continue to provide water access if they were modified. The other four recreation areas (Illia Landing, Willow Landing, Garfield County Ramp, and Little Goose Landing) would be closed if the Little Goose Dam was breached. Although the ramps at Boyer Park and Central Ferry State Park could continue to provide access, the marina at Boyer Park would not be replaced nor would the boat basin at Central Ferry State Park. Under Alternative 4—Dam Breaching, there would be no boat moorage facilities available along the section of river that flows through what is now Lake Bryan.

Because the river elevation would be between 18 and 113 feet below current pool levels, none of the developed swimming facilities would remain functional. Depending upon future road access, parking, and sanitation facilities, it is likely that dispersed swimming would occur along this stretch of river as natural beaches emerge or are formed.

Upland recreational facilities at the two recreation areas that would potentially remain open under Alternative 4—Dam Breaching would also be impacted. Although the Boyer Park boat ramp could be relocated to provide access, it is not known if the Port of Whitman County would keep Boyer Park open if there was no moorage capability. If Boyer Park were to remain open, relocating irrigation intakes and relocating facilities closer to the water would have to be implemented to keep the park in operation. The upland recreation facilities at Central Ferry State Park would be less affected by Alternative 4—Dam Breaching than Boyer Park. The boat ramp and staging area would be relocated.

The breaching of the Little Goose Dam would result in the elimination of the dam as a bridge connecting Little Goose Dam Road and vehicular access to the north and south sides of the river. This would force some local recreationists to either cross downriver at the Lyon's Ferry Bridge (which is 11 river miles downriver from the dam), or upriver at the Central Ferry Bridge (which is 13 river miles upriver from the dam) to gain access to opposite sides of the river.

The following is a brief description of the effects that Alternative 4—Dam Breaching would have on the individual recreation areas at Little Goose.

Illia Dunes

The river would be between 18 and 23 feet below the existing pool elevation ranges. Because there are no developed water-oriented facilities at Illia Dunes, the main effect Alternative 4—Dam Breaching would have on this recreation area would be that the beach area adjacent to the river would be much wider than the beach adjacent to Lake Bryan.

Boyer Park and Marina

Under Alternative 4—Dam Breaching, the river would be between 18 and 23 feet below the current pool elevation ranges. The three-lane boat ramp, handling dock, marina, marine dump station, public gas dock, tour boat dock, and swimming beach would not be usable and irrigation intakes could be affected. Although the marina and related facilities would not be useable, boat ramps would be relocated to allow river access. In addition to losing water-oriented facilities, the dry boat storage facility and the motel could be affected by Alternative 4—Dam Breaching due to a decrease in customers. Access to Boyer Park and Marina (which is located on the north side of the river) would be more difficult than it is currently for some local recreationists, particularly in communities such as Pomeroy that are located south of the river.

Illia Landing

The river would be between 18 and 23 feet below the existing pool elevation ranges. The area would be closed.

Willow Landing

Under Alternative 4—Dam Breaching, the river would be between 58 and 63 feet below the existing pool elevation ranges and the two-lane boat ramp would not be functional. The area would be closed.

Garfield County Ramp

The river would be between 78 and 83 feet below existing pool elevation ranges. The primitive two-lane boat ramp would not be usable and the area would be closed.

Central Ferry State Park

Under Alternative 4—Dam Breaching, the river would be between 88 and 93 feet below the current pool elevation ranges. The four-lane boat ramp, handling docks, boat embayment, marine dump, and developed beach area would not be usable and the 60-unit campground would be farther from the water than it is currently.

Little Goose Landing

The river would be between 108 and 113 feet below the existing pool elevation ranges. The one-lane boat ramp and handling dock would not be usable and the area would be closed.

Lower Monumental (Lake Herbert G. West)

Three (Lyons Ferry Marina, Ayers Boat Basin and Devil's Bench) of the five recreation areas that provide boat access to Lake West would be closed with Alternative 4—Dam Breaching. Texas Rapids and Lyons Ferry State Park could provide access to the river if their ramps were extended. The Lyon's Ferry marina is leased to the Port of Columbia and has moorage for 44 boats, a restaurant/grocery store and other amenities. If Alternative 4—Dam Breaching is implemented, the Port would likely close the facility, which would eliminate all boat moorage and possibly use of the boat ramp. Alternative 4—Dam Breaching would also leave the developed swimming area at Lyons Ferry State Park unusable. It is likely that undeveloped swimming areas would evolve as beaches along the river were formed.

The upland facilities at Lower Monumental that would be most affected by Alternative 4—Dam Breaching would be the facilities at the Lyons Ferry Marina and Lyons Ferry State Park. If the Lyons Ferry Marina is closed, most if not all of the upland facilities such as the campground, the restaurant/grocery store, and the marina grounds would likely close.

The breaching of the Lower Monumental Dam would eliminate the dam as a crossing point for County Highway 263. Recreationists desiring to cross the river to access the other side would have to cross either downriver at the U.S. Route 12 bridge (which is

40 river miles downriver from the dam) or upriver at Lyon's Ferry Bridge (which is 17 river miles upriver from the dam).

The following is a brief look at the effects Alternative 4—Dam Breaching would have on the individual recreation areas at Lower Monumental.

Riparia

There would be very little effect on this recreation area under Alternative 4—Dam Breaching because the existing boat ramp has silted closed. The primary use of Riparia is for fishing access.

Texas Rapids

Under Alternative 4—Dam Breaching, the river would be between 32 and 35 feet below the current pool range. The two-lane boat ramp and dock would not be usable and the irrigation intake would be affected. The ramp would be relocated.

Lyons Ferry State Park

The river would be between 62 and 65 feet below the existing pool range. The two-lane boat ramp, the handling dock and the swimming beach would not be usable, and the irrigation system in the day-use area and comfort station area could be affected. The boat ramp would be relocated to provide river access.

Lyons Ferry Marina

With Alternative 4—Dam Breaching, the river would be from 62 to 65 feet below current operating ranges. The marina and boat ramp would not be usable and irrigation intakes would be affected. Much of the campground would overlook a sizable dewatered area. The marina would be closed.

Ayer Boat Basin

Under Alternative 4—Dam Breaching, the river would be from 92 to 99 feet below the current pool elevation range and the boat tunnel that goes under the railroad to connect the boat basin would be dry. The area would be closed.

Devil's Bench

The river would be between 102 and 105 feet below the existing pool range and the two-lane boat ramp would not be usable. The area would be closed.

Ice Harbor (Lake Sacajawea)

Five of the six recreation areas that provide access to Lake Sacajawea could continue to provide access to the river under Alternative 4—Dam Breaching if their ramps were extended. The sixth area, the North Shore ramp, would be removed to allow for the river to bypass the dam. The two recreation areas that have marina-moorage capabilities (Charbonneau Park and Fishhook Park) would no longer have those capabilities if Alternative 4—Dam Breaching were implemented. By having the river

between 12 and 95 feet lower than the existing pool elevation ranges, the four developed swimming areas (Charbonneau Park, Levey Park, Fishhook Park, and Windust Park) would not be usable. It is possible that beaches at several of the recreation areas would be naturally established and would likely be used by recreationists.

The upland recreation areas at Ice Harbor would be much higher and farther away from water than is currently the case. Moving some facilities or building new facilities would allow people that use the facilities to do so closer to water. Because three of the recreation areas are very popular, particularly with people from the Tri-Cities, it is likely that more efforts will be made at several of these recreation areas to reconfigure the parks.

The following is a brief look at the effects Alternative 4—Dam Breaching would have on the individual recreation areas at Ice Harbor.

Windust Park

The river would be from 12 to 15 feet below current pool elevations and would result in the one-lane boat ramp and developed swimming beach being unusable. There would also be potential problems with the irrigation intakes, and the day-use area would no longer be adjacent to the water. The boat ramp would be modified to provide access to the river.

Fishhook Park

Near Fishhook Park, the river would be from 72 to 75 feet below the existing pool range. As a result, the two-lane boat ramp, staging area, handling docks, temporary moorage, and sanitary dump stations would not be functional. Irrigation intakes would not work and there would likely be other irrigation problems. In addition, the day-use area and campground would not have direct water access. The moorage facilities would not be able to be relocated, but the boat ramp could be relocated.

Levey Park

Under Alternative 4—Dam Breaching, the river would be from 92 to 95 feet lower than the existing pool range. The two-lane boat ramp, handling docks, staging area, sanitary dump station and developed beach could no longer be used. Irrigation intakes would also likely be unusable and the day-use area would not be adjacent to water. The boat ramp would be modified to provide river access.

Charbonneau Park

The river would be from 92 to 95 feet below the existing pool ranges. As a result, the marina, marina dump, two-lane boat ramp, and developed beach would not be functional. In addition, to use the irrigation intakes they would have to be relocated and some additional work might be required on the irrigation system. The boat ramp would be modified.

North Shore Ramp

The entire area near the dam that contains the ramp and other recreation facilities would be removed for the installation of the new free-flowing river channel.

5.12.4.2 Effects on Dispersed Recreation Sites

There are numerous undeveloped dispersed recreation sites along the shores of the Lower Snake River Project. Some of these sites are simply pullovers adjacent to a highway that provide water access for anglers. Others are larger areas where people picnic, swim, and participate in other day-use activities. None of these dispersed sites have developed facilities such as restrooms, formal trails, or formal parking.

Alternative 4—Dam Breaching would make the shoreline further from existing dispersed sites and at the same time provide some new areas suitable for dispersed uses. If Alternative 4—Dam Breaching were implemented, the river would be between approximately 8 and 100 feet below existing dispersed sites. Because the features that attract people to the sites (such as beaches or embayments) would disappear with the elimination of the lakes, the use patterns of many dispersed areas would change. Some sites would simply cease to be used because the features that attracted people would be eliminated. Other sites would be so high above or far away from the river that access would be difficult and/or dangerous. These sites would likely also be abandoned.

The reestablishment of the river under Alternative 4—Dam Breaching would result in new dispersed sites evolving. Over a period of several years, the river and silty shoreline would stabilize and features such as beaches would form. These features would attract users and new dispersed areas would evolve, but use of such sites would likely be regulated to minimize impacts to fish, wildlife, and cultural resources. Many of the passive activities that occur now at dispersed sites would also occur at new dispersed sites. If allowed by managing agencies, river recreationists would also likely create dispersed sites at locations such as beaches and embayments that could only be accessed by the river.

5.12.4.3 Effects on Recreational Activities and Visitation

Alternative 4—Dam Breaching would cause significant changes in the mix and types of outdoor recreational activities that would take place along the lower Snake River. Water-based recreation activities would change from flat-water to river-oriented. Some activities, such as shoreline fishing that occur at the reservoirs, could also occur on the river, although the amount of shoreline area would decrease under Alternative 4—Dam Breaching. The participation rates for propeller boat-oriented activities (such as water skiing) and sailing would drop off significantly. It would take a number of years for participation rates for many activities to return to pre-breaching levels and some activities never would.

It is interesting to note that in a survey of recreationists (primarily local) conducted by Washington State University prior to the completion of Lower Granite, 75 percent of the respondents believed that Lower Granite would detract from their recreational enjoyment of the area (Corps, 1975). The primary activities of people at that time were sightseeing (including driving for pleasure), fishing, and hunting. Whether

these people came to eventually accept and enjoy reservoir recreation opportunities or were displaced is not known.

In addition to changes in types of recreational activities available in the project area, there would be changes in visitation patterns and use levels. These changes would have local, and to a lesser extent, regional economic effects.

The following sections describe the likely effects that Alternative 4—Dam Breaching would have on existing and new recreational activities, visitation patterns, and income generated by recreation.

Effects on Recreational Activities

The types of recreation activities currently available at the reservoirs would be drastically changed after breaching. Lake or flatwater-oriented recreation activities such as some types of boating pleasure, water skiing, fishing for some warm-water species, and sightseeing in the current type of tour boats that cruise between Portland and Lewiston would essentially be eliminated under Alternative 4—Dam Breaching. They could be replaced with river-based recreation activities such as drift boating, rafting, kayaking, and jet boating. Commercial jet boat tours through the lower Snake River from Portland or the Lewiston-Clarkston areas could replace some of the visitation that would be lost by losing the cruise ships. However, it is likely that a different mix of visitor types would subscribe to jet boat services verses those that now go on cruise ships.

As with the other alternatives, the level of future usage would largely depend on the population of anadromous fish that would be available for sports fishing harvest, and on how desirable the recovering river and riparian environment is perceived by the public in a post drawdown condition. Overall, both recreational fishing and general recreation would be expected to increase within 10 years as the river is restored and fish populations respond to natural river conditions.

Displacement of Current Users

Breaching the four dams would affect recreation locally and to a lesser extent regionally. Flatwater recreational opportunities would be replaced at the four reservoirs with river-oriented recreational opportunities. Some flatwater recreationists would adapt to the new conditions. These recreationists would either attempt to use the river setting for their existing activities (as modified) or would substitute other activities. Other recreationists, however, would find a river setting unsuitable to their needs and would either discontinue their flatwater activity or travel to another site. Lakes and reservoirs in the general region that might receive displaced recreationists include Lake Coeur d' Alene, Lake Pend Oreille, Priest Lake, Dworshak Lake (part of the year), and the lower Columbia reservoir projects. If the John Day reservoir is similarly drawn down, flatwater-dependent recreationists that currently use John Day will also be displaced and may travel to other regional reservoirs and lakes to recreate.

New Activities

To estimate the effects of Alternative 4—Dam Breaching on river-oriented recreation, Corps recreation planners estimated how long it would take for the river and adjacent land to reach conditions that were most suitable for river-oriented recreational activities. Table 5.12-3 estimates in percentages the expected suitability of various types of river recreation in 5-year increments following dam removal. For example, 5 years after dam removal, it is estimated that the condition of the river would be 50 percent of its optimal suitability for jet boating and jet skiing. Over time, the river's adjacent environment would stabilize through development of riparian vegetation and would probably become more and more conducive to jet boating and jet skiing. By 20 years after dam removal, it is believed that conditions would be well suited for these types of activities.

Table 5.12-3. Recreation Suitability Recovery after Dam Removal[1/]

Activity	Year 1	Year 5	Year 10	Year 20
Jet Boating, Jet Skiing	0.2	0.5	0.7	1
Rafting/Kayaking/Canoeing	0.3	0.5	0.8	1
Swimming	0.2	0.4	1	1
Picnic/Primitive Camping	0.8	1	1	1
Developed Camping	0.6	0.9	1	1
Hiking & Mtn. Biking	0.8	1	1	1
Hunting	0.5	0.8	1	1

1/ The numbers in this table represent an estimate of the percentage of optimal suitability at various years that could be accommodated on the Lower Snake River after dam removal.

Reaching optimal suitability for other water-based recreation activities would also be expected to take a number of years. This is due to several factors including the number of years it would take for the river to stabilize, the initial lack of river access facilities, the time it would take for riparian areas to revegetate and the time it would take for sport fish populations to recover sufficiently for recreational fishing. Land-based activities would recover faster than water-based activities. Although many of the land-based recreational activities such as campgrounds and picnic areas would no longer be located next to lakes, they still could be used as the dewatered areas of the old reservoirs recover. Moving existing facilities, building new facilities, and redesigning existing facilities along with careful planning of revegetation efforts near recreational facilities (so that new plantings would not visually separate recreation areas from the river) would allow recreationists to participate in land-based activities sooner than water-based activities.

The following describes how some of the more popular recreational activities would recover after dam breaching.

Fishing

Fishing activity the first years following breaching would probably be low because the populations of most resident fish (yellow perch, bullheads, catfish and bluegill) would be reduced after breaching and steelhead and salmon populations would not have recovered sufficiently to allow recreational fishing. It is estimated that there would be a one third reduction in warm water fish carrying capacity with a natural

river (Normandeau and Bennett, 1999). Two resident fish species that would likely repopulate after dam removal in numbers significant enough to permit recreational fishing would be smallmouth bass and sturgeon. This would allow for warm water recreational fishing. It should be noted that in the Lower Granite EIS, smallmouth bass fishing in the pre-dam section of the Snake River that flowed through Lower Granite was considered to be high quality (Corps, 1975).

Based on the NMFS analysis, it is considered likely that both native and hatchery salmon and steelhead populations will eventually recover sufficiently to allow recreational fishing on the lower Snake River. Fishing success after breaching would also likely be enhanced downstream and upstream of the breached lower Snake River dams. The increase in fish populations along with the modification of existing recreational facilities (or the construction of new facilities) would allow anglers to increase their participation rates. As steelhead, salmon and to a lesser extent smallmouth bass and sturgeon populations would increase, so would fishing activity.

River fishing use for salmon and steelhead was determined by availability of these species as estimated by NMFS fisheries biologists and generalized by the DREW Anadromous Fish Workgroup (1999). Specifically, these fish numbers were used to estimate the number of angler hours of salmon and steelhead fishing that could be supported, given current catch rates for steelhead and expected catch rates for salmon.

Jet Boating and Jet Skiing

Although there is currently some use of jet boats and jet skis at the four lower Snake River facilities, is anticipated that there would be greater use of these watercraft with dam breaching. It is estimated that it would take between 20 and 30 years after dam removal for conditions to become optimally suitable for jet boating and jet skiing. After one year, conditions would likely allow for use that would be 15 percent of that which would occur when the river is optimally suitable. Within 5 years, boat ramps and other boat access facilities would be reestablished and conditions for jet boating and jet skiing would be 40 percent of demand. By year 20, conditions would be 75 percent of demand and after 30 years 100 percent.

Rafting/Kayaking/Canoeing

As the river would stabilize, these types of activities would become very popular and could be as popular as they are on the section of the Snake River above Lewiston, Idaho. Dam removal is expected to result in the re-emergence of 63 named, relatively small rapids and numerous islands and sand beaches. These features would be appealing to many recreationists. In addition, it is estimated that during the high flow months of April to June, the entire 140 miles of river could be floated in approximately one week. Shorter segments of the river with closer put-in and take-out locations could be floated in a day or over weekends.

As the river stabilizes over time, fish populations would increase and revegetation would make the dewatered areas more attractive. As a result, participation rates would be expected to increase. By the end of the first year after breaching, river conditions would be 10 percent of demand for these activities. By Year 5, conditions would be 20 to 30 percent of demand and by Year 10, 40 to 60 percent. After 20 years, the river would be at 90 percent of demand and 30 years 100 percent.

Swimming

With dam breaching, none of the developed swimming beaches that exist would be useable. It is unlikely that the Corps or other agencies would build new developed beaches on large free-flowing river segments due to concerns regarding safety. Swimming, however, could likely occur at informal or dispersed locations depending on future management restrictions. As the river stabilizes, natural beaches would become established that would be similar to those on the Snake River upstream from Lewiston. It is interesting to note that in the Lower Granite EIS, the authors of a recreation user survey conducted by Washington State University reported that survey respondents felt that the loss of natural sand beaches would be one of the greatest negative recreation impacts on existing recreation at the Lower Granite facility (Corps, 1975).

It is estimated that river and shoreline conditions one year after breaching would be 10 percent of optimally suitable. After 5 years, the level would increase to 40 percent and after approximately 20 years, conditions would be suitable to support 100 percent of demand for swimming.

Land-based Activities

Participation levels for land-based recreational activities would recover faster than levels for water-based activities. Activities that can occur at dispersed areas such as picnicking, primitive camping, hiking, and mountain bike riding would recover faster than activities such as camping at developed facilities. After breaching, old road and railroad beds would re-emerge along the shoreline of the river. It may be possible to restore or convert some of these road and/or railroad beds into trails for hiking, mountain biking, and horseback riding. After the first year, it is estimated that land and river conditions would be such that for dispersed activities they would be 80 percent of optimally suitable. After 5 years, conditions for these activities would be suitable to meet all demand.

Although many of the developed land-based recreational facilities such as campgrounds and picnic areas would no longer be located next to water, they still could be used. Moving or redesigning existing facilities, building new facilities, and carefully planning revegetation efforts in dewatered areas (so that new plantings would not block views of the river and would help cut down on dust) would encourage recreationists to participate in land-based activities. Although the greater distance to water from sites that are currently near water would be construed as a negative by many users, it is felt that by year 10, conditions for camping should be optimally suitable.

5.12.4.4 Recreation Use and Economic Benefits

Five recreation use surveys were conducted as part of this study by the Drawdown Regional Economic Workgroup (DREW) Recreation Workgroup. Five of these surveys were designed to identify and value current recreation use. These surveys targeted different stretches of the river and different types of recreation activity. Two separate surveys, an angler survey and a general recreation survey, were mailed to a sample of recreationists who visited the lower Snake River reservoirs from May to October 1997. A survey was also mailed to a sample of anglers who fished the 30 mile stretch of the Snake River above Lewiston, Idaho from September 1997 to

March 1998. An angler survey was also distributed to anglers in Central Idaho. These surveys and their findings are discussed in more detail in Technical Appendix I, Economics. Existing reservoir use and annual benefits involved 500,172 trips worth $33,254,000 a year. Corps' estimates of current visitation show over one million visitors to the lower Snake River reservoirs and associated recreation facilities (see Table 4.13-3). Total existing recreation use identified through these surveys involved 640,685 trips worth $38,524,000 a year (Table 5.12-4).

The DREW Recreation Workgroup also surveyed a much larger sample of Washington, Idaho, Oregon, western Montana, and California residents to identify the type and number of recreation users that would visit the lower Snake River if the dams were breached. The survey described the new recreation conditions and asked whether the respondent would visit and, if so, how many times a year. Respondents were also asked the distance, travel cost, and travel time to the spot on the river that they would be most likely to visit. A total of 4,780 completed surveys were returned for a response rate of 54 percent. The survey findings were then applied to all Washington, Idaho, Oregon, western Montana, and California residents. The results of this survey indicate that a large percentage of total river recreation trips would come from more distant areas such as Portland, Seattle, and California. This differs from current conditions where a large proportion of outdoor recreationists and anglers reside within 50 miles of the four reservoirs.

Table 5.12-4. Existing Recreation Surveys, Number of Trips, and Annual Benefits

Survey	Number of Completed Surveys	Response Rate (%)	Number of Trips[1/]	Willingness-to-Pay per Trip[1/]	Annual Benefits (000s of dollars)
Reservoir Angler	537	59	57,388	29.23	1,676
Reservoir General Recreation (excludes Angling)	408	65	442,834	71.31	31,578
Upriver Angler	247	72	11,437	35.71	408
Central Idaho Angling	257	na	129,026	37.68	4,862
Total	**1,449**	**na**	**640,685**	**na**	**38,524**

1/ The number of trips and the willingness-to-pay per trip were estimated based on each survey. The surveys asked how many trips each individual takes a year and how much each trip costs them. This travel cost is used to compute an individual's willingness-to-pay for recreation. Annual benefits are calculated by multiplying the number of trips by the willingness-to-pay per trip.
Source: DREW Recreation Workgroup, 1999 (pages 1-4 and Table R-1)

Four different demand estimates and two estimates of willingness-to-pay per trip were generated for Alternative 4—Dam Breaching. Annual trips to a free-flowing lower Snake River were estimated to range from 245,338 to 1,756,193 by the 10th year following breaching. Recreation use following dam breaching would be phased in over time as the natural river system recovered from breaching (see Table 5.12-3). Use would also be constrained by existing facilities–developed campgrounds, dispersed campgrounds, and boat ramp capacity. Facilities were, however, projected to increase over time as river conditions stabilized. Salmon and steelhead fishing demand would be constrained by the availability of fish and only a small fraction of projected angler demand would be met.

The average annual effects are presented for Alternatives 2 through 4 in Table 5.12-5. These values, presented in 1998 dollars, represent the net change from Alternative 1—Existing Conditions, which is the base case for this analysis. Average annual costs were calculated based on a 100-year period of analysis at three discount rates—6.875 percent, 4.75 percent, and 0.0 percent. The data presented in Table 5.12-5 indicate that there are significant recreation benefits associated with breaching the dams. These data also indicate that the majority of these benefits would be associated with recreation activities other than fishing. However, benefits associated with fishing alone would replace a large portion of the reservoir recreation benefits that would be lost under this alternative. There would also be benefits associated with small projected gains in salmon and steelhead fishing under Alternatives 2 and 3.

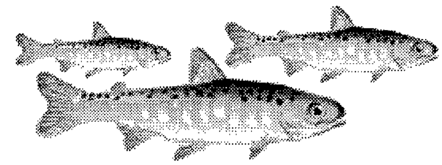
Table 5.12-5. Average Annual Economic Effects by Discount Rate (000s of dollars)

	6.875 % Discount Rate		4.75 % Discount Rate		0.0 % Discount Rate	
	Minimum	**Maximum**	**Minimum**	**Maximum**	**Minimum**	**Maximum**
Alternative 2						
Reservoir Recreation	0	0	0	0	0	0
River Recreation	0	0	0	0	0	0
Recreational Fishing	2,026	2,026	1,990	1,990	1,420	1,420
Total	2,026	2,026	1,990	1,990	1,420	1,420
Total Point Estimate		2,026		1,990		1,420
Alternative 3						
Reservoir Recreation	0	0	0	0	0	0
River Recreation	0	0	0	0	0	0
Recreational Fishing	2,076	2,076	1,970	1,970	1,180	1,180
Total	2,076	2,076	1,970	1,970	1,180	1,180
Total Point Estimate		2,076		1,970		1,180
Alternative 4						
Reservoir Recreation	-31,600	-31,600	-31,600	-31,600	-31,600	-31,600
River Recreation	36,180	150,120	38,100	158,300	44,000	182,600
Recreational Fishing	6,746	32,916	8,220	37,440	12,750	52,220
Total	11,326	151,436	13,246	159,616	19,146	183,916
Total Point Estimate		81,381		86,431		101,531

Notes:

1. The numbers presented for Alternative 4 represent the low demand estimate and a composite of the low and high willingness-to-pay value. These issues are discussed in more detail in Technical Appendix I, Economics.
2. Benefits are presented net of Alternative 1—Existing Conditions, which is considered the base case for this analysis.
3. The recreational fishing category includes mainstem salmon, resident, and steelhead species and tributary salmon and steelhead species.

Source: DREW Recreation Workgroup, 1999 (Tables R-4A through R-4C)



5.13 Social Resources

This section is divided into three sections that correspond with the three main areas of concern addressed in Section 4.14, Social Resources. Section 5.13.1 outlines the impacts to regional employment, income, and population projected under each alternative. This discussion is based on the regional analysis conducted for this study by the DREW Regional Workgroup. Section 5.13.2 addresses communities. This discussion is based on the social analysis conducted for this study by the DREW Social Analysis Workgroup (1999) and the two-phase community-based social impact assessment conducted by a team of social scientists from the University of Idaho (Harris et al., 1999a, 1999b). Section 5.13.3 addresses potential effects to low income and minority populations. A summary of the potential effects of the alternatives on social resources is presented on Table 5.13-1.

5.13.1 Regional Demographics and Employment

Preceding sections of this FR/EIS discuss the effects that the proposed alternatives would have on power, transportation, water supply, and other aspects of the regional and national economy. These sections address the physical aspects of these changes, as well as the costs that would be incurred by producers and, in the case of power, consumers. Increased or reduced spending associated with these changes would also affect the regional economy. Inflows or outflows to or from the local economy cause business activity to change by a multiple of the original change. An influx of funds, for example, is spent and re-spent in the local economy as expanding sectors hire labor and buy business inputs and services from local suppliers. This process is known as the multiplier effect. The more locally-produced goods and services

Table 5.13-1. Summary of the Potential Effects of the Alternatives on Social Resources

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Employment	No change from current and projected future conditions.	Minor job gains associated with implementation spending and avoided costs.	Minor job gains associated with implementation spending and avoided costs.	• The lower Snake River region would gain about 20,790 temporary jobs spread over a 10-year period. • Short-term employment gains would also be associated with rail car storage construction in Oregon (63 jobs). • The lower Snake River region would gain 2,277 permanent jobs with an average annual income of $22,266, but lose 2,988 jobs with an average annual income of $33,066. The estimated net change in permanent jobs in the lower Snake River region would be -711. • About 2,382 jobs would also be lost throughout the Pacific Northwest. Changes in anadromous fish harvest would result in the creation of approximately 198 jobs in the Pacific Northwest, California, British Columbia, and Alaska.
Income	No change from current and projected future conditions.	Minor income gains associated with implementation spending and avoided costs.	Minor income gains associated with implementation spending and avoided costs.	• Short-term increases in personal income in the lower Snake River region would be about $676.7 million spread over 10 years. • Short-term gains in personal income would also be associated with rail car storage construction in Oregon ($1.8 million) • In the long-run, total personal income in the lower Snake River region would decrease by about $46.1 million. • Changes would also occur throughout the Pacific Northwest with a long-term decrease of $244.6 million. Changes in anadromous fish harvest would increase personal income in the Pacific Northwest, California, British Columbia, and Alaska by about $10.6 million.
Population	The lower Snake River study area population is projected to increase by 182,000 or 31.4 percent from 1995 to 2020.	Minor fluctuations in population associated with the employment changes noted above.	Minor fluctuations in population associated with employment changes.	• Employment changes would result in a short-term increase in population but a long-term loss. These changes would be larger than under the other alternatives but minor compared to population changes predicted for the region.

Table 5.13-1. Summary of the Potential Effects of the Alternatives on Social Resources
Page 2 of 2

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Communities	No change from current and projected future conditions.	• Minor effects but some communities located upriver may be adversely affected by lower probabilities of salmon recovery. • Uncertainty surrounding the future of the dams may negatively affect some communities.	• Minor effects but some communities located upriver may be adversely affected by lower probabilities of salmon recovery. • Uncertainty surrounding the future of the dams may negatively affect some communities.	• Upriver communities would likely gain jobs from recreation and tourism associated with a free-flowing river and to a lesser extent increased fish runs. Job losses may occur in the forest products sector as a result of the loss of river navigation. • Communities in the reservoir subregion would likely experience a net decrease in employment due to reductions in Corps' employment and increased pressure on family farms. • Downriver communities would lose jobs if farms presently irrigated from Ice Harbor go out of business. These losses would be partially offset by gains in transportation- and power generation-related employment. • Adverse community effects perceived by residents of communities in the lower Snake River region included decreases in population, tax revenues, businesses, property values, agricultural base, declining schools, as well as increased traffic congestion and business failure. • Other lower Snake River region communities with more tourist-oriented economies perceived benefits. • Residents of southern Idaho communities perceived impacts ranging from somewhat beneficial to very adverse. Beneficial effects were associated with increased fish runs. Negative effects included increased transportation and utility costs.
Low Income and/or Minority Populations	Would do "little or nothing" to correct the cumulative inequities that tribes have suffered from construction and operation of the four dams.	Would do "little or nothing" to correct the cumulative inequities that tribes have suffered from construction and operation of the four dams.	Would do "little or nothing" to correct the cumulative inequities that tribes have suffered from construction and operation of the four dams.	• Increased salmon would benefit the tribes as would the exposure of approximately 14,000 acres of presently inundated lands. • Hispanic workers employed on farms irrigated from Ice Harbor Reservoir would lose their jobs. If these farms go out of business.

purchased, the larger the multiplier effect. A reduction in spending also has indirect and induced effects. Closure of a business in a particular community, for example, has predictable impacts on other firms located in that community. Loss of a business results in less local spending of workers' wages and salaries, and less local spending for business inputs and services. Therefore, making the total impact to the economy larger than the initial change.

The regional economic analysis developed for this study addresses the regional economic impacts of changes in spending projected by various DREW workgroups. These impacts, evaluated in terms of jobs and income, were estimated using input-output models, which model the interactions among different sectors of the economy. These models estimate the effects of changes in one sector on the rest of the regional economy. Eight input-output models were constructed to address potential regional effects associated with the alternatives. Models were developed for Washington, Oregon, Idaho, and Montana, the upriver, downriver, and reservoir subregions, and the lower Snake River study area, which consists of the three subregions (see Table 4.14-1 and Figure 4.14-1). The subregion models were developed to examine cases, such as a reduction in irrigated agriculture on Ice Harbor Reservoir, where impacts are relatively localized. Evaluating localized changes using a statewide model would tend to overestimate the impact. States are less dependent on imports than smaller regions and, therefore, tend to have larger multiplier effects. The state models are used to evaluate impacts, such as increases in electric rates, that occur at a larger scale. State models were also used by the DREW Anadromous Fish Workgroup to assess the regional impacts of changes in anadromous fish harvest.

The impacts to regional employment and income summarized in the following sections are presented as net changes from existing conditions. The DREW Regional Workgroup projected changes to employment and income over a 100-year study period. Job totals include both full- and part-time employment. One limitation of this type of regional impact analysis is that it presents a picture of the economy at a single point in time. This picture is based on historical ratios between different sectors of the economy rather than a dynamic structure of changing relationships. It has been suggested that this type of analysis tends to overstate actual impacts because it assumes that all possible adjustments to disturbance are instantaneous and permanent, and that individual responses to disturbances are limited. People who lose a job, for example, are assumed to stay unemployed. In reality, people and businesses adjust over time, as they consider and try alternative occupations, technologies, and locations (IEAB, 1999).

The economy of the lower Snake River study area and the Pacific Northwest as a whole has changed since 1970. Historically important job sectors such as logging, mining, and farming and ranching have declined or remained stagnant over this period, while employment in the services sector has dramatically increased. Non-labor sources of income, particularly transfer payments, have increased as a component of total regional income (see Section 4.14.1, Regional Demographics and Employment). Employment is projected to increase significantly over the next 20 or so years in the states of Washington, Idaho, and Oregon. Projected increases range from 33.6 percent in Washington to 67.3 percent in Idaho, with a projected increase for all three states of 1,199,655 jobs. The Washington Office of Financial

Management (1999), for example, asserts that the state's economy will become increasingly diversified as the majority of the projected growth will be in retail and services industries. These projected increases and the evolving structure of the Pacific Northwest economy form a backdrop against which changes in employment projected for the proposed alternatives should be considered. Although resource-based industries, such as logging and farming, will likely decline as a share of total employment, they will remain important parts of the region's economic base, especially in small communities where they may be the dominant source of employment (see Figure 4.14-4). While projected job changes may represent a small percentage of existing and projected employment, the loss of these jobs would be very significant for the individuals concerned and the communities where job losses may be concentrated. Potential impacts to communities are discussed in Section 5.13.2, Communities.

The regional analysis is discussed in detail in the DREW Regional Analysis report (DREW Regional Workgroup, 1999) and Technical Appendix I, Economics (Section 6.0).

5.13.1.1 Employment

Alternative 1—Existing Conditions

Alternative 1—Existing Conditions is the baseline for this analysis. Employment associated with this alternative is summarized in Section 4.14.1, Regional Demographics and Employment. Total full- and part-time employment in the 25-county lower Snake River study area was 318,740 in 1995. Combined employment for the states of Washington, Idaho, and Oregon was 6,216,449.

Alternative 2—Maximum Transport of Juvenile Salmon

Employment change under this alternative would be relatively minor and limited to jobs associated with implementation and avoided costs. Employment associated with implementing this alternative from 2001 to 2004 is projected to range from a loss of 110 jobs to a gain of 69 jobs compared to Alternative 1—Existing Conditions. Changes in the Corps' operating expenditures (avoided costs) would result in 83 less jobs from 2001 to 2026 than Alternative 1—Existing Conditions.

Alternative 3—Major System Improvements

Employment change under this alternative would also be relatively minor and limited to jobs associated with implementation and avoided costs. Employment associated with implementing this alternative from 2001 to 2006 is projected to range from a loss of 67 jobs to a gain of 495 jobs compared to Alternative 1—Existing Conditions. Changes in the Corps' operating expenditures (avoided costs) would result in 44 more jobs than Alternative 1—Existing Conditions from 2001 to 2026 and 25 more jobs from 2027 to 2100.

Alternative 4—Dam Breaching

Employment effects associated with this alternative can be divided into short- and long-term effects. Short-term effects, mainly associated with construction activities, would be temporary and last less than 10 years (Table 5.13-2). Long-term effects would be permanent (Table 5.13-3). These impacts caused by changes in spending include indirect and induced jobs. Therefore, jobs gained and lost are distributed throughout the regional economy and not only concentrated in the sector where the initial change in spending occurs. These effects are discussed in detail in Technical Appendix I, Economics (Section 6.0).

Table 5.13-2. Short-Term Employment Effects (Jobs)1/

	Upriver	Reservoir	Downriver	Total Lower Snake River Study Area2/	State3/
1995 Employment	75,081	92,535	151,124	318,740	6,216,449
Power Plant Construction4/	0	0	5,572	5,572	2,786
Transmission Line Construction	0	0	2,080	2,080	0
Rail Construction5/				872	0
Road Construction5/				1,972	0
Facilities Construction5/				6,982	0
Transportation					
Tidewater Railcar Storage Construction				0	63
Well Modification	0	916	259	1,175	0
Pump Modification	844	0	0	844	0
Implementation	259	517	517	1,293	0
Total Change	**1,103**	**1,433**	**8,428**	**20,790**	**2,849**
Change as % of 1995 Employment	1.47	1.55	5.58	6.52	0.05

1/ Midpoints are shown when only lower and upper bounds were available from other DREW workgroups. Averages are shown when the effects vary by year over a number of years.

2/ The three subregions comprise the lower Snake River study area. Employment change in this area is the sum of employment change across the three subregions.

3/ This column addresses impacts that occur outside the lower Snake River study area. The 1995 combined state employment total is for Washington, Oregon, Idaho, and Montana. In this case, impacts are limited to power plant construction that would likely occur in the Puget Sound region of Washington and tidewater railcar storage construction, which would take place in Oregon.

4/ The DREW Hydropower Impact Team (DREW HIT) assumed that a total of six replacement power plants would be built. The exact locations of these plants are unknown but DREW HIT assumed that three would be located in the downriver subregion, with the other three most likely located in the Puget Sound region. Construction of each power plant is estimated to generate 2,786 short-term jobs. The estimates shown in this table are the maximum number of these jobs that would be generated in any one year—5,572 in the downriver subregion, where two plants would be constructed simultaneously, and 2,786 jobs in the Puget Sound region, where the projected replacement plants would likely be constructed at different times.

5/ These effects would occur in the lower Snake River study area but it is not known how they would be distributed among the subregions.

Source: DREW Regional Workgroup, 1999

Table 5.13-3. Long-Term Employment Effects (Jobs) [1/]

	Upriver	Reservoir	Downriver	Total Lower Snake River Study Area[2/]	State[3/]
1995 Employment	75,081	92,535	151,124	318,740	6,216,449
O&M Spending on Replacement Power Plants & New Transmission Lines[3/]	0	0	884	884	876
Increased Recreation (inc. Angling)[4/]				1,393	0
Commercial Fishing[5/]					249
Total Long-term Employment Gain	**0**	**0**	**884**	**2,277**	**1,125**
Reduced Spending due to Increased Electric Bills					(2,382)
Reduction in Irrigated Lands	0	(1,105)	(474)	(1,579)	0
Avoided Costs (Reductions in Corps' Spending)	(133)	(1,060)	(133)	(1,326)	0
Reduced Cruise Ship Operations	(83)	0	0	(83)	0
Total Long-term Employment Loss	**(216)**	**(2,165)**	**(607)**	**(2,988)**	**(2,382)**
Net Long-term Employment Change	(216)	(2,165)	277	(711)	(1,257)
Net Change as a % of 1995 Employment	(0.29)	(2.34)	0.18	(0.22)	(0.02)

1/ Midpoints are shown when only lower and upper bounds were available from other DREW workgroups. Averages are shown when the effects vary by year over a number of years.

2/ The three subregions comprise the lower Snake River study area. Employment change in this area is the sum of employment change across the three subregions.

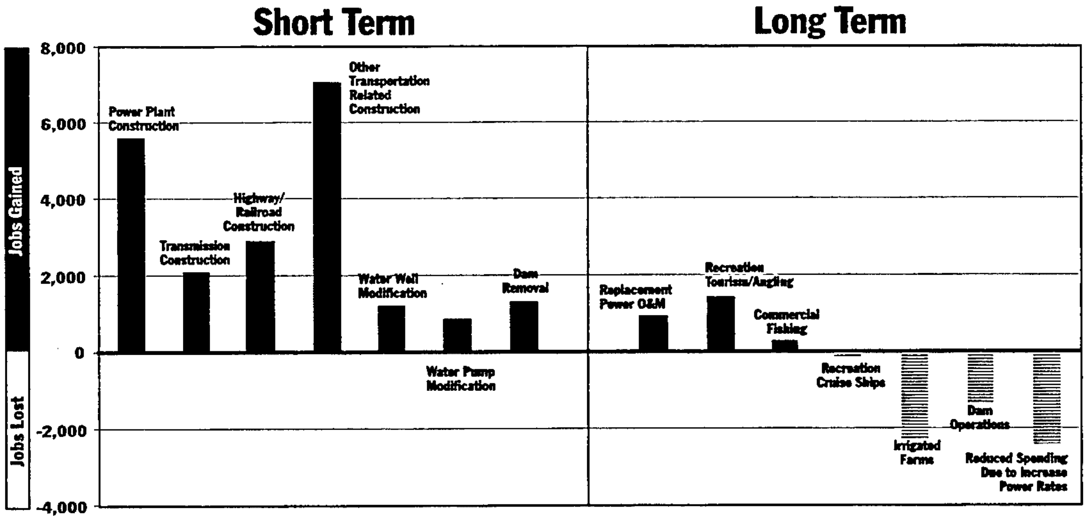
3/ This column addresses impacts that occur outside the lower Snake River study area. The 1995 combined state employment total is for Washington, Oregon, Idaho, and Montana. In this case, impacts outside the lower Snake River study area include commercial fishing impacts that would occur throughout the Pacific Northwest, California, British Columbia, and Alaska. The majority of these jobs (about 80 percent) would be created in the Pacific Northwest. Power plant operations and maintenance spending would also generate jobs outside the lower Snake River study area. Employment loss associated with the reduced consumer and business spending that would result from to increased electric bills would occur throughout the Pacific Northwest.

4/ These effects would occur in the lower Snake River study area, but it is not known how they would be distributed among the subregions.

5/ The commercial fishing total includes a small number of jobs that would be associated with increases in ocean recreational fisheries.

Source: DREW Regional Workgroup, 1999

Projected short- and long-term effects are summarized graphically in Figure 5.13-1. Construction activities resulting directly and indirectly from breaching the four lower Snake River dams would result in a total of about 20,790 temporary jobs being generated in the lower Snake River study area over a 10-year period. The exact number of jobs would fluctuate from year-to-year. This activity would generate a temporary increase in personal income of about $677 million or an average annual income of $32,548 per job ($677 million/20,790 jobs). Major construction projects would include replacement power facilities (5,572 jobs) and new grain elevators (6,982 jobs). There would also be short-term employment gains associated with power plant construction in the Puget Sound region of Washington and tidewater railcar storage construction in Oregon.



Notes:
1. Short-term impacts would be temporary and last less than 10 years.
2. Long-term impacts would be permanent and continue.
3. Effects are presented net of the base case (Alternative 1—Existing Conditions).
4. Short-term and long-term employment estimates for each resource area range from low to high and vary from year to year. These point estimates are either average, mid-point numbers, or "most likely" estimates provided by DREW workgroup leaders.
5. Increased electricity rates and transportation costs may cause affected firms or plants to reduce output and employment or possibly close or relocate to another region. Potentially-affected industries include aluminum manufacturing, paper manufacturing, and grain farms. Substantial proprietary information would be required to predict how individual firms would react to cost increases. As a result, possible job losses in these sectors are unknown. This is discussed further in Technical Appendix I, Economics (Section 6.0).

Figure 5.13-1. Short- and Long-Term Employment Change

In the long-run, the lower Snake River study area would gain 2,277 jobs with an average annual income of $22,266. These jobs would mainly be associated with the operation of replacement power facilities and recreation activities. The lower Snake River study area would, however, lose 2,988 jobs with an average annual income of $33,066. The lost jobs would be mainly associated with Corps' operations and farmland irrigated from Ice Harbor Reservoir. The average annual income in the lower Snake River study area in 1995 was $32,088. This estimated net change in long-term jobs (-711 jobs) represents less than 1 percent of 1995 employment in the Lower Snake River study area.

Reduced spending associated with increased power rates would result in an additional 2,382 long-term jobs being lost throughout the Pacific Northwest. Changes in anadromous fish harvest would result in the creation of approximately 249 long-term jobs in the Pacific Northwest, California, British Columbia, and Alaska. Power plant operation and maintenance spending would generate 884 jobs in the Puget Sound region of Washington. The estimated total net change in long-term jobs (-1,968 jobs) represents less than 0.1 percent of total Pacific Northwest employment in 1995. This total includes net jobs lost in the lower Snake River study area (-711 jobs),

throughout the Pacific Northwest (-2,382 jobs), and jobs created in the Pacific Northwest, California, British Columbia, and Alaska (198 jobs). The majority of the jobs associated with anadromous fish harvest (about 80 percent) would be created in the Pacific Northwest.

Short-term and long-term employment estimates for each resource area range from low to high and vary from year to year. The point estimates presented here are based on mid-point numbers or "most likely" estimates provided by the other DREW workgroups and present a snapshot of the maximum or most likely job changes that could occur in only one year. These numbers indicate of the type and magnitude of employment changes that would be associated with Alternative 4—Dam Breaching. Another way to view these changes is to examine the net annual change (Figure 5.13-2). Figure 5.13-2 suggests that despite the initial short-term construction boom, the long-term employment impact of breaching the four lower Snake River dams would be negative.

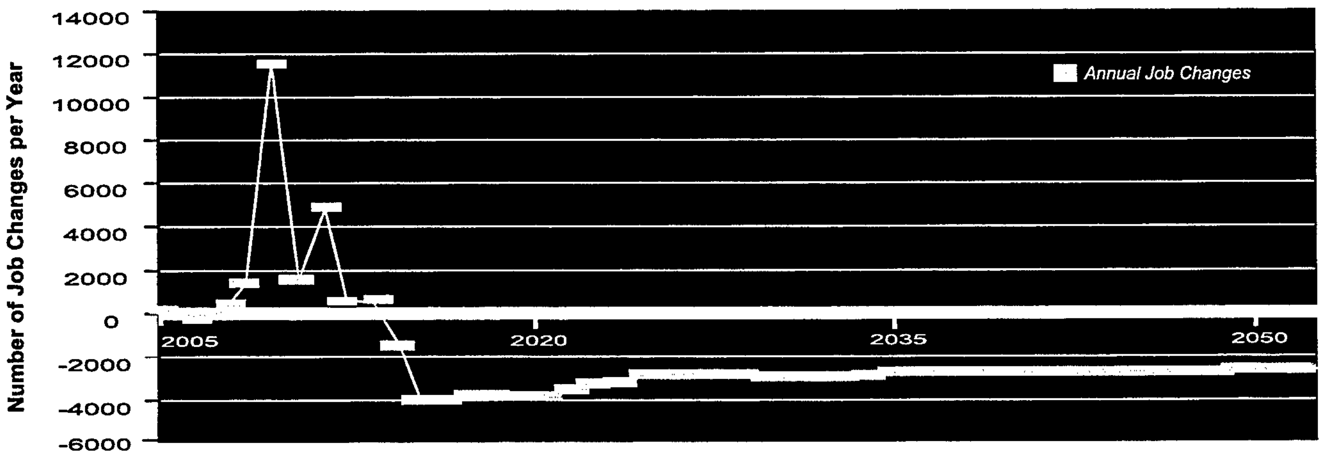


Figure 5.13-2. Net Annual Employment Change (2005-2055)

5.13.1.2 Income

Alternative 1—Existing Conditions

Alternative 1—Existing Conditions is the baseline for this analysis. Total personal income in the 25-county lower Snake River study area was $10,725,338 million in 1995.

Alternative 2—Maximum Transport of Juvenile Salmon

Changes in personal income under this alternative would be associated with implementation and avoided costs. Changes in income associated with implementing this alternative from 2001 to 2004 are projected to range from a loss of $3.01 million to a gain of $0.67 million compared to Alternative 1—Existing Conditions. Changes in the Corps' operating expenditures (avoided costs) would result in a loss of $2.36 million from 2001 to 2026.

Alternative 3—Major System Improvements

Changes in personal income under this alternative would also be associated with implementation and avoided costs. Changes in income associated with implementing this alternative from 2001 to 2006 are projected to range from a loss of $1.8 million to a gain of $13.51 million compared to Alternative 1—Existing Conditions. Changes in the Corps' operating expenditures (avoided costs) would result in a gain of $1.26 million in personal income over Alternative 1—Existing Conditions from 2001 to 2026 and $0.73 million from 2027 to 2100.

Alternative 4—Dam Breaching

Changes in personal income mirror the changes in jobs discussed in the preceding section. Personal income effects associated with this alternative can be divided into short- and long-term effects. Short-term effects, mainly associated with construction activities, would be temporary and last less than 10 years. Long-term effects would be permanent. These impacts are summarized by subregion and state in Tables 5.13-4 and 5.13-5. These effects are caused by changes in spending patterns including indirect and induced jobs. Therefore, associated changes in income are distributed throughout the regional economy and are not only concentrated in the sector where the initial change in spending occurs. These effects are discussed in detail in Technical Appendix I, Economics (Section 6.0).

Net changes in short-term and long-term personal income are presented by subregion in Tables 5.13-4 and 5.13-5, respectively. Short-term gains are evident in all three subregions and range from 1.33 percent in the upriver subregion to 5.7 percent of existing personal income in the downriver subregion. Short-term increases in personal income in the lower Snake River study area would be about $676.7 million spread over 10 years. There would also be short-term gains in personal income associated with Power plant construction in the Puget Sound region of Washington ($104.8 million) and tidewater rail car storage construction in Oregon ($1.8 million).

In the long-run total personal income in the lower Snake River study area would increase by $52.7 million. This increase in income would mainly be associated with the operation of replacement power facilities and recreation activities. The lower Snake River study area would, however, experience a decrease in personal income of about $98.8 million. This lost income would be mainly associated with Corps' operations and farmland irrigated from Ice Harbor Reservoir. This estimated net change in long-term income (-$46.1 million) represents about 0.43 percent of total personal income in the lower Snake River study area in 1995.

Reduced spending associated with increased power rates would result in an additional long-term loss of personal income of $220.3 million in the Pacific Northwest. Changes in anadromous fish harvest would result in a long-term gain of about $10.6 million in personal income spread over the Pacific Northwest, California, British Columbia, and Alaska. Power plant operations and maintenance spending would generate increased personal income of $23.6 million. This estimated net long-term income change (-$244.6 million) represents less than 0.1 percent of total Pacific Northwest income in 1995. This total includes net income lost in the lower Snake River study area (-$46 million), throughout the Pacific Northwest (-$208.5 million),

Table 5.13-4. Short-Term Income Effects ($ million per year)[1/]

	Upriver	Reservoir	Downriver	Total Lower Snake River Study Area[2/]	State[3/]
1995 Total Income	2,215	3,071	5,440	10,725	234,487
Power Plant Construction [4/]	0.0	0.0	209.6	209.6	104.8
Transmission Line Construction	0.0	0.0	78.3	78.3	0
Rail Construction[5/]				27.9	0
Road Construction[5/]				63.1	0
Transportation Facilities Construction[5/]				202.0	0
Tidewater Railcar Storage Construction					1.8
Well Modification	0.0	29.5	8.3	37.9	0
Pump Modification	22.4	0.0	0.0	22.4	0
Implementation	7.1	14.2	14.2	35.5	0
Total Change	29.5	43.7	310.4	676.7	106.6
Change as % of 1995 Income	1.33	1.42	5.7	6.3	0.45

1/ Midpoints are shown when only lower and upper bounds were available from other DREW workgroups. Averages are shown when the effects vary by year over a number of years.

2/ The three subregions comprise the lower Snake River study area. The change in personal income in this area is the sum of income change across the three subregions.

3/ Impacts addressed in this column occur outside the lower Snake River study area. The 1995 combined state income total is for Washington, Oregon, Idaho, and Montana. In this case, these types of impacts are limited to power plant construction that would likely occur in the Puget Sound region of Washington and tidewater railcar storage construction which would take place in Oregon.

4/ The DREW Hydropower Impact Team (DREW HIT) assumed that a total of six replacement power plants would be built. The exact locations of these plants are unknown but DREW HIT assumed that three would be located in the downriver subregion, with the other three most likely located in the Puget Sound region. Construction of each power plant is estimated to generate 2,786 short-term jobs. The estimates shown in this table are the maximum number of these jobs that would be generated in any one year—5,572 in the downriver subregion, where two plants would be constructed simultaneously, and 2,786 jobs in the Puget Sound region, where the projected replacement plants would likely be constructed at different times.

5/ These effects would occur in the lower Snake River study area but it is not known how they would be distributed among the subregions.

Source: DREW Regional Workgroup, 1999

Table 5.13-5. Long-Term Income Effects1/ ($ Million per Year)[1/]

	Upriver	Reservoir	Downriver	Total Lower Snake River Study Area[2/]	State[3/]
1995 Income	2,215	3,071	5,440	10,725	234,487
O&M Spending on Replacement Power Plants & New Transmission Lines	0.0	0.0	23.6	23.6	23.6
Increased Recreation (inc. Angling)[4/]				29.1	0
Commercial Fishing[5/]					10.6
Total Long-term Increase in Income	**0.0**	**0.0**	**23.6**	**52.7**	**33.6**
Reduced Spending due to Increased Electric Bills					-232.1
Reduction in Irrigated Lands	0.0	-41.1	-17.6	-58.6	0
Avoided Costs (Reductions in Corps' Spending)	-3.8	-30.3	-3.8	-37.9	0
Reduced Cruise Ship Operations	-2.3	0.0	0.0	-2.3	0
Total Long-term Loss of Income	**-6.0**	**-71.4**	**-21.4**	**-98.8**	**-232.1**
Net Long-term Change in Income	-6.0	-71.4	2.2	-46.1	-198.5
Net Change as a % of 1995 Income	-0.27	-2.32	0.05	-0.43	-0.08

1/ Midpoints are shown when only lower and upper bounds were available from other DREW workgroups. Averages are shown when the effects vary by year over a number of years.

2/ The three subregions comprise the lower Snake River study area. Change in personal income in this area is the sum of income change across the three subregions.

3/ Impacts addressed in this column occur outside the lower Snake River study area. In this case, impacts outside the lower Snake River Study area include commercial fishing impacts that would occur throughout the Pacific Northwest, California, British Columbia, and Alaska. The majority of this income (about 80 percent) would be generated in the Pacific Northwest. Power plant operations and maintenance spending in the Puget Sound region would also generate increases outside the lower Snake River study area. The loss of personal income associated with the reduced consumer and business spending that would result from increased electric bills would occur throughout the Pacific Northwest.

4/ These effects would occur in the lower Snake River study area, but it is not known how they would be distributed among the subregions.

5/ The commercial fishing total includes a small amount of income associated with increased ocean recreational fisheries.

Source: DREW Regional Workgroup, 1999

and income gained in the Pacific Northwest, California, British Columbia and Alaska ($10.6 million), and the Puget Sound region ($23.6 million).

5.13.1.3 Population

It is difficult to predict with any degree of certainty the effect that individual actions, such as the alternatives proposed under this FR/EIS, will have on regional population. For this analysis, changes in regional employment associated with each alternative are used to identify potential trends in population. These trends are compared with the existing population projections identified in Table 5-13-6. Population is projected to grow in all three subregions. Population in the downriver subregion, for example, is expected to increase by 113,961 or 35.4 percent between 1995 and 2020. Large

Table 5.13-6. Population Projections 2000 to 2020 (in thousands)

	1995-2000				2000-2010			2010-2020			1995-2020	
	1995	2000	Absolute Change	% Change	2010	Absolute Change	% Change	2020	Absolute Change	% Change	Absolute Change	% Change
Downriver	322	351	30	9.3	392	40	11.5	435	44	11.1	114	35.4
Reservoir	134	141	7	5.2	156	15	10.3	171	15	9.8	37	27.3
Upriver	125	130	5	4.4	142	12	9.0	157	15	10.3	32	25.5
Total Study Area	**580**	**623**	**43**	**7.3**	**690**	**67**	**10.7**	**763**	**73**	**10.7**	**182**	**31.4**
Oregon	3,141	3,406	265	8.4	3,857	451	13.2	4,326	469	12.2	1,185	37.7
Washington	5,431	5,850	419	7.7	6,693	843	14.4	7,610	917	13.7	2,179	40.1
Idaho	1,163	1,281	118	10.1	1,493	212	16.5	1,708	215	14.4	545	46.9
Total State	**9,735**	**10,537**	**802**	**8.2**	**12,043**	**1,506**	**14.3**	**13,644**	**1,601**	**13.3**	**3,909**	**40.2**

Source: Projections for 2000, 2010, and 2020 are from the State of Washington, Office of Financial Management (1999); State of Oregon, Office of Economic Analysis (1997); Idaho Power (1999); Data for 1995 are from Table 4.14-2.

increases are also projected for each state over this period. The population of Idaho, for example, is expected to increase by 545,048 people or 46.9 percent.

The following sections discuss potential population changes associated with each alternative.

Alternative 1—Existing Conditions

Alternative 1—Existing Conditions is the base case condition for this analysis. Representative population projections are presented in Table 5.13-6.

Alternative 2—Maximum Transport of Juvenile Salmon

The average household size for the states of Washington, Oregon, and Idaho was 2.59 persons in 1990. The relatively minor fluctuations in employment associated with this alternative could affect regional population. These effects would, however, be minor compared to the population projections presented in Table 5.13-6.

Alternative 3—Major System Improvements

The relatively minor fluctuations in employment associated with this alternative could also affect regional population. These effects, like those associated with Alternative 2—Maximum Transport of Juvenile Salmon, would be minor compared to the population projections presented in Table 5.13-6.

Alternative 4—Dam Breaching

Net employment changes associated with dam breaching are presented in Tables 5.13-2 and 5.13-3. Under this alternative, short-term employment in the lower Snake River study area would increase by 20,790 jobs. If all of these workers were hired from outside the region and decided to relocate with their families, this would represent a population increase of 53,846 or 9 percent of the 25-county study area population in 1995. Given the size of the available labor force in the region and the temporary nature of much of this employment, it is, however, unlikely that potential population increases would approach this level.

Long-term employment in the lower Snake River study area would decrease. It is possible that people who would have filled these positions in the lower Snake River study area either relocate or do not move to the region in the first place. If this were the case with all 711 jobs, there would be a reduction in population of about 1,841 people or about 0.3 percent of the area's 1995 population. Net job loss throughout the Pacific Northwest would be 2,895. It is unlikely that these projected reductions would cause significant fluctuations in the population of the Pacific Northwest. The combined population of Washington, Oregon, and Idaho—almost 10 million in 1995—is projected to grow by about 3.9 million between 1995 and 2020 (Table 5.13-6).

5.13.2 Communities

The majority of communities in the Lower Snake River study area are small rural towns that have moderate or low economic diversity. The agricultural and wood products sectors continue to play a major role in many local communities even though they have declined as a source of regional employment and income over the past decade. The following discussion draws on the findings of the DREW Social Analysis (DREW Social Analysis Workgroup, 1999) and the findings of a series of community forums conducted in the lower Snake River study area and southern Idaho by a team of social scientists from the University of Idaho (UI) (Harris et al., 1999a, 1999b).

These studies provide two different but complementary approaches to community impact assessment. The DREW Social Analysis developed estimates of potential impacts to nine focus communities using information provided by the other DREW workgroups, NMFS, secondary data analysis, key informant interviews, and existing studies. Potential impacts were estimated in terms of percentage change from existing conditions for a range of social indicators (Table 5.13-7).

The UI community-based social impact assessment involved asking community residents to estimate the likely effects of the proposed alternatives on their communities 20 years into the future. The interactive community forum process provided a rich source of information and insights into key issues, concerns, and perceptions of impacts. Forums were conducted in 18 communities in the lower Snake River study area, including the nine examined in the DREW Social Analysis. Information gathered during these forums included each community's perceptions of its history, an assessment of its current situation, and a projection of potential social impacts under each proposed alternative. The current assessment developed by each community is summarized in Table 4.14-8. In general, community residents perceived the impacts of the proposed alternatives, particularly Alternative 4—Dam Breaching, to be larger than those identified by the DREW Social Analysis Workgroup. Projected future impacts are summarized by community type and community in Table 5.13-8.

Both the DREW Social Analysis and the UI community-based social impact assessment found that changes in the physical, biological, and human environment would have both adverse and beneficial effects on communities throughout the study area. Projected effects would create both winners and losers within the region, the

Table 5.13-7. Significance of Changes in the Physical, Biological, and Socioeconomic Environment

Alt.	Indicators/Impact Measure	Evaluation Criteria [2/]	Clarkston	Colfax	Kennewic	Lewiston	Orofino	Pasco	Pomeroy	Riggins	Umatilla
	Power										
4	Residential Rate Increases	Residential Rate Increase > 5 percent			X			X			
4		Residential Rate Increase < 5 percent	X	X		X	X		X	X	X
4	Rate Employment Impacts	Decrease in Employment< 1 percent	X	X	X	X	X	X	X	X	X
4	Power Provider Rate Risk	Public Owned Utility			X			X		X	
4		Investor Owned Utility	X	X		X	X		X		X
4	Fixed Income Ratepayers	Poverty Rate >10 percent of all families	X		X			X		X	X
4		Poverty Rate < 10 percent of all families		X		X	X		X		
4	New Power Plant Operation	Increase in Employment < 1 percent			X			X			X
4	ST: New Plant Construction	Increase in Regional Employment > 5 percent			X			X			X
4		Within 50 miles of Potential Plant Siting			X			X			X
	Recreation										
4	Non-Fishing River Recreation	Increase in Employment> 1 percent	X	X					X		
4		Increase in Employment < 1 percent			X	X		X			
4		Short-term Displacement	X	X	X	X		X	X		
4		Short-Term Crowding			X			X			X
4	Anadromous Fishing Recreation	Increase in Employment > 1 percent								X	
4		Increase in Employment < 1 percent	X	X	X	X	X	X			
4		Short-term Displacement	X			X	X	X			
4		Short-Term Crowding					X	X			
4		Local Fishing Opportunities	X	X	X	X	X	X	X	X	X
4	Site Access	Decrease in Site Access > 25 percent	X	X		X			X		
4		Decrease in Site Access <25 percent			X		X	X		X	X
4	Site Services	Decrease in Site Services> 25 percent	X	X		X			X		
4		Decrease in Site Services< 25 percent			X		X	X		X	X
4	Elderly Recreationists	Over 65 years > 20 percent	X	X					X		
4		Over 65 years < 20 percent			X	X	X	X		X	X
	Transportation										
4	Transportation Related Employment	Increase in Employment > 1 percent									
4		Increase in Employment < 1 percent	X	X	X	X	X	X	X		
4	Farm Spending Related Employment	Decrease in Employment > 1 percent		X							
4		Decrease in Employment < 1 percent	X			X	X		X	X	
4	Dryland Farm Income	Decrease in Total County Farm Income > 10 Percent		X						X	
4		Decrease in Total County Farm Income < 10 percent	X			X	X	X	X		
4	ST: Road, Rail and Infrastructure	Increase in Employment > 1 percent	X	X	X	X			X		
4		Increase in Employment < 1 percent					X	X			

Table 5.13-7. Significance of Changes in the Physical, Biological, and Socioeconomic Environment

Alt.	Indicators/Impact Measure	Evaluation Criteria [2/]	Clarkston	Colfax	Kennewic	Lewiston	Orofino	Pasco	Pomeroy	Riggins	Umatilla
4	Grain Transportation Costs	Increase in Avg. Cost > 15 cents per bushel	X	X		X	X			X	
4		Increase in Avg. Cost < 15 cents per bushel						X	X		
4	Farm Consolidation (Dryland)	Risk of Increased rate of Farm Consolidation	X	X		X	X		X	X	
4	Transportation Costs (other Shippers)	Increase in Transportation Cost	X	X		X	X		X	X	
4	Transportation Capacity Uncertainty	Increase in Transportation Uncertainty	X	X	X	X	X	X	X	X	
4	Highway Congestion	Increase in Traffic Volume > 2 percent						X	X		
4		Increase in Traffic Volume < 2 percent	X	X	X	X					
4		Decrease in Traffic Volume					X			X	
4	Highway Safety	Increase in Highway Safety					X			X	
4		Decrease in Highway Safety	X	X	X	X		X	X		
	Water Supply										
4	Dislocated Agricultural Workers/Spending	Decrease in Employment > 1 percent			X			X			
4		Decrease in Employment < 1 percent									X
4	Farm Income	Decrease in Total County Farm Income > 10 Percent						X			
4	ST: Pump/Well Modifications	Increase in Employment > 1 percent	X			X					
4		Increase in Employment < 1 percent		X	X		X	X	X		
4		Increased costs for well irrigators/users	X			X		X	X		
	Effects on Food Processors	Decrease in local produce			X			X			X
	Implementation/Avoided Costs										
4	ST: Implementation Employment	Increase in Employment > 1 percent	X	X			X		X		
4		Increase in Employment < 1 percent			X	X		X			X
3		Increase in Employment < 1 percent	X	X	X	X	X	X	X		
4	Outside Workers	Increase in Outside Workers >10 percent	X						X		
4		Increase in Outside Workers < 10 percent		X	X	X		X			
4	Human Movement Patterns	Loss of Project Bridges within 50 miles		X	X			X	X		
4	Operations Employment	Decrease in Employment > 1 percent		X					X		
4		Decrease in Employment < 1 percent	X		X	X		X			X
3		Increase in Employment < 1 percent	X		X	X		X	X		X
	Anadromous Fish Recovery										
4/3	ST: Social Cohesion	Increased Social Cohesion		X	X			X	X	X	X
4/3		Decreased Social Cohesion	X			X	X				
4	Recovery Uncertainty/Risk	Lower Uncertainty of Salmon Recovery	X	X	X	X	X	X	X	X	X
3		Higher Uncertainty of Salmon Recovery	X	X	X	X	X	X	X	X	X
3	Business Uncertainty/Risk	Lower Economic Uncertainty/Risk	X	X	X	X	X	X	X	X	X
4		Higher Economic Uncertainty/Risk	X	X	X	X	X	X	X	X	X

Table 5.13-7. Significance of Changes in the Physical, Biological, and Socioeconomic Environment

Alt.	Indicators/Impact Measure	Evaluation Criteria 2/	Clarkston	Colfax	Kennewic	Lewiston	Orofino	Pasco	Pomeroy	Riggins	Umatilla
3	Extinction Risk/Existence Value	Higher Extinction Risk	X	X	X	X	X	X	X	X	X
4		Lower Extinction Risk	X	X	X	X	X	X	X	X	X
	Other Social Effects										
4	Population Impacts	Decrease in Population > 5 percent						X			
4		Decrease in Population < 5 percent		X	X				X		
4		Increase in Population < 5 percent	X			X	X			X	X
4											
4	Total Long-Term Employment	Employment Losses < 5 percent	X	X	X	X	X	X	X		X
4		Increase Net Employment > 1 percent									
4		Increase Net Employment < 1 percent	X			X	X			X	X
4		Decrease Net Employment < 1 percent		X	X			X	X		
4	Total Short-Term Employment	Increase in Employment > 5 percent	X	X					X		
4		Increase in Employment < 5 percent			X	X	X	X			X
4	Total Subregional Employment	Increase Net Employment < 1 percent			X	X	X	X		X	
4		Decrease Net Employment > 1 percent	X	X					X		
4	Aesthetics	ST Exposed Shoreline	X	X	X	X	X	X	X		
4		LT Revegetated Shoreline	X	X	X	X	X	X	X		

1/ Uncertainty related to employment percentages is a result of uncertainties faced by other DREW workgroups, dynamics of local economies and methodology for allocating regional impacts to local geographic area.

2/ Percentage increases expressed in terms of less or greater than 1 percent range from 0 to 2 percent. Changes greater than 5 percent are all less than 15 percent

ST=short-term employment associated with construction.

Table 5.13-8. Perceptions of Change by Community and Community Type

Community Dimension	Typical Community Case	Alt. 1 Median Rating[1/]	Alt. 3 Median Rating[1/]	Alt. 1 to 3 Rating Justifications	Alt. 4 Median Rating	Alt. 4 Rating Justifications
Trade Center Community Type						
People	Lewiston, ID Clarkston, WA Kennewick, WA Pasco, WA	1.5 4.0 2.0 2.0	1.0 3.0 1.5 2.0	• No highly replicated justifications	-3.5 -4.0 -4.0 -5.0	• Decreasing population • High public assistance • Ethnic diversity is low • Lack of industry and job opportunities • Decreased school enrollment • Less people own their own homes • Loss and/or change in recreation opportunities
Jobs & Wealth	Lewiston, ID Clarkston, WA Kennewick, WA Pasco, WA	1.5 4.0 2.5 1.5	1.5 4.0 1.5 1.5	• Increased utility rates	-3.5 -5.0 -4.5 -5.0	• Declining economy • Decrease in income/wages • Decreased job opportunities • Increased cost of doing business
Place	Lewiston, ID Clarkston, WA Kennewick, WA Pasco, WA	1.5 3.5 2.0 1.0	1.5 3.0 1.5 1.5	• Current trends continue	-2.5 -4.0 -4.5 -5.0	• Increased traffic congestion • Inadequate social services • Loss of community • Lack of transportation facilities • Loss and/or decrease in farming • Increased business vacancies and struggling business
Vision & Vitality	Lewiston, ID Clarkston, WA Kennewick, WA Pasco, WA	1.0 3.0 2.0 2.0	1.5 3.0 1.5 2.0	• Current trends continue • Good community vitality	-2.0 -4.5 -4.5 -5.0	• Pessimistic vision • Reduced/limited budgets • Decreasing vitality • Diminishing and/or decline in leadership capacity
Highly Productive Dryland Agriculture Community Type						
People	Colfax, WA Genesee, ID Pomeroy, WA	1.0 2.0 -1.0	0 2.0 -1.0	• Current trends continue	-4.0 2.5 -5.0	• Decreased population • Families become less stable • Decreased school enrollment
Jobs & Wealth	Colfax, WA Genesee, ID Pomeroy, WA	-1.0 2.0 2.0	0 1.0 1.0	• Current trends continue • Increased utility rates • Short-term jobs created	-4.0 -3.5 -4.0	• Increased utility rates • High transportation costs • Decreased job opportunities • Decreased agricultural jobs • Decreased income/wages • Increased unemployment • Increased cost of doing business • Decreased tax base • Decreased property values • Jobs and wealth change regardless of alternatives

Table 5.13-8. Perceptions of Change by Community and Community Type

Community Dimension	Typical Community Case	Alt. 1 Median Rating[1/]	Alt. 3 Median Rating[1/]	Alt. 1 to 3 Rating Justifications	Alt. 4 Median Rating	Alt. 4 Rating Justifications
Place	Colfax, WA Genesee, ID Pomeroy, WA	0 2.0 1.0	0 2.0 1.0	• Current trends continue	-4.0 -3.0 -3.5	• Inadequate infrastructure • Inadequate social services • Increased cost of living • Lack of transportation facilities • High traffic congestion • Increased business vacancies • Less pride and sense of place in the community • Inadequate public areas • Decreased number of farms and farm families • Inadequate air and water quality
Vision & Vitality	Colfax, WA Genesee, ID Pomeroy, WA	0 2.0 1.0	0 1.0 0	• Current trends continue	-3.0 -3.0 -3.5	• Pessimistic vision • Lost tax revenue • Reduced budgets
Productive Dryland Agriculture Community Type						
People	Kahlotus, WA Washtucna, WA	2.5 2.0	1.5 2.0	• No highly replicated justifications	-5.0 -4.0	• No highly replicated justifications
Jobs & Wealth	Kahlotus, WA Washtucna, WA	2.0 1.0	2.0 1.5	• Increased jobs	-5.0 -4.0	• Decreased job opportunities • Increased utility rates • Decreased tax base • Poor roads from increased trucking
Place	Kahlotus, WA Washtucna, WA	1.5 1.0 1.0	2.0 1.5 1.5	• Current trends continue	-5.0 -4.0 -4.0	• Lack of transport facilities • Decreased recreation and tourism opportunities • Negative impacts from increased trucking
Vision & Vitality	Kahlotus, WA Washtucna, WA	1.0 1.0	2.0 1.5	• No highly replicated justifications	-5.0 -3.0	• Leadership decline
Multiple Natural Resource Use Community Type						
People	Enterprise, OR Orofino, ID Riggins, ID Weippe, ID	-1.0 2.0 -2.0 1.0	-1.0 1.0 -2.0 0	• Current trends continue	0 -3.0 1.0 -3.0	• Current trends continue
Jobs & Wealth	Enterprise, OR Orofino, ID Riggins, ID Weippe, ID	-1.0 2.0 -1.5 1.5	0	• No highly replicated justifications	-2.0 -4.0 1.0 -2.0	• Increased cost of living
Place	Enterprise, OR Orofino, ID Riggins, ID Weippe, ID	-1.0 2.0 -2.0 1.0	-1.0 2.0 -2.0 0	• Current trends continue	0 -4.0 0 -2.0	• Increased transportation (economic, air & water quality, etc.)
Vision & Vitality	Enterprise, OR Orofino, ID Riggins, ID Weippe, ID	-1.0 1.0 0 0	-1.0 1.5 0 0	• Current trends continue	-1.0 -3.0 1.5 -3.0	• Current trends continue

Table 5.13-8. Perceptions of Change by Community and Community Type

Community Dimension	Typical Community Case	Alt. 1 Median Rating[1/]	Alt. 3 Median Rating[1/]	Alt. 1 to 3 Rating Justifications	Alt. 4 Median Rating	Alt. 4 Rating Justifications
Snake River Irrigated Agriculture Community Type						
People	Prescott, WA	1.0	1.0	• Current trends continue	-4.0	• Decreased population • Families become less stable • People change for the worse • Lack of industry and job opportunities
Jobs & Wealth	Prescott, WA	1.0	1.0	• Current trends continue	-4.0	• Decreased job opportunities • Jobs decrease due to the ripple effect from agricultural losses • Increased utility rates • Business down/loss of business • Decreased property values
Place	Prescott, WA	1.0	1.0	• Current trends continue	-4.0	• Public areas/appearance worsens • Increased vacancies & businesses struggle • Traffic congestion • Ruin of community • Infrastructure in bad shape
Vision & Vitality	Prescott, WA	1.0	1.0	• Current trends continue	-5.0	• Diminished civic organization capacity • Insufficient tax base • Inadequate fiscal resources • Limited quality social activities
Columbia River Agriculture Community Type						
People	Adams, OR Burbank, WA Stanfield, OR Umatilla, OR	1.5 2.0 4.0 3.0	1.5 2.0 3.0 2.5	• Current trends continue	-3.0 -5.0 -0.5 -4.5	• Unstable economy
Jobs & Wealth	Adams, OR Burbank, WA Stanfield, OR Umatilla, OR	1.0 2.0 4.0 3.0	1.0 2.0 4.0 3.0	• No highly replicated justifications	-3.0 -5.0 -0.5 -5.0	• Increased utility rates • Shrinking agriculture base • Job losses from agricultural decline
Place	Adams, OR Burbank, WA Stanfield, OR Umatilla, OR	1.0 2.0 4.0 3.0	1.0 2.0 2.0 2.5	• Current trends continue	-3.0 -5.0 -2.0 -5.0	• Inadequate infrastructure • Increased traffic congestion • Decreased farming • Loss of opportunities for parks and open spaces and recreation and tourism • Decreased air and water quality • Higher taxes • Community will be ruined
Vision & Vitality	Adams, OR Burbank, WA Stanfield, OR Umatilla, OR	2.0 2.0 4.0 2.5	2.0 1.0 4.0 2.5	• No highly replicated justifications	-3.5 -5.0 0 -5.0	• Decline in civic capacity

[1/] Participants were asked to forecast the likely effects of each alternative on their community and rate changes across four community dimensions—people, jobs and wealth, place, and vision and vitality—for 2020. These ratings ranged from –5 ("adversely affected" by the alternative) to +5 ("beneficially affected" by the alternative) relative to existing conditions. This table presents the median rating assigned to each dimension by community.

subregion, and individual communities. Economic and social losses for one community or group may present opportunities for gains by another community or group.

5.13.2.1 Community Social Impacts

The DREW Social Analysis examined nine focus communities—Clarkston, Colfax, Kennewick, Pasco, and Pomeroy in Washington; Lewiston, Orofino, and Riggins in Idaho; and Umatilla in Oregon (Figure 4.14-1). These communities were selected to capture a range of positive and negative impacts across different types of communities located throughout the region. Specific estimates of potential impacts by Alternative 4—Dam Breaching to each community are summarized in Table 5.13-7. These nine focus communities are divided evenly over the three subregions. The following discussion addresses potential impacts that are likely to be common to other communities located in their respective subregions.

Alternative 1—Existing Conditions

Alternative 1—Existing Conditions is considered the base case for this analysis.

Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 3 —Major System Improvements

Alternatives 2 and 3 would have little effect on the existing social and economic environment for the majority of the communities located in the lower Snake River region. Some communities, particularly those located upriver (e.g., Lewiston, Orofino, and Riggins), could be adversely affected by lower probabilities of salmon recovery. Uncertainty about the future of the four lower Snake River dams may also have negative social effects on some communities.

Alternative 4—Dam Breaching

Breaching the four lower Snake River dams would change the physical and economic environment of the Lower Snake River study area. Communities in the upriver region (e.g., Lewiston, Orofino, and Riggins) would likely experience net employment gains as a result of expected increases in recreation and tourism associated with a free-flowing river, and to a lesser extent increased fish runs. The extent of the effects upon Lewiston and Orofino are, however, uncertain because the possible effects that the loss of river navigation could have upon the forest products industry have not been completely analyzed. Detailed industry studies would be needed to fully evaluate the extent of these effects. In the absence of these studies, potential impacts associated with the wood products industry are assessed qualitatively in Technical Appendix I, Economics (Section 6.0). The effects of increased transportation costs to farmers would be most significant for communities located in the upriver subregion. Communities in Latah, Nez Perce, Idaho, and Lewis counties in Idaho would experience the largest increases in transportation costs.

Communities located in the reservoir subregion (e.g., Pomeroy, Colfax, and Clarkston) would likely experience a net decrease in employment due to reductions in Corps' employment and increased pressure on family farms caused by increased

transportation, storage, and handling costs for agricultural products. This added pressure to an already depressed agricultural sector may lead to an increased rate of farm consolidation for those farms with a high debt to equity ratio.

Communities located in the downriver subregion (e.g., Pasco, Kennewick, and Umatilla) would likely experience employment loss if farms presently irrigated from Ice Harbor reservoir go out of business. These losses could be partially offset by expected increases in transportation- and power generation-related employment.

Overall adverse community impacts associated with Alternative 4—Dam Breaching that were identified by the DREW Social Analysis Workgroup include:

- Decreased net farm income and increased financial pressure on dryland farmers throughout the region, particularly those farms located in close proximity to the lower Snake River
- Risk of increased consolidation of family farms and a decrease in rural farm population
- Decreased county property tax base in 20 regional counties from decreased farm land value and potential loss of irrigated lands
- Dislocated full-time and seasonal workers from Ice Harbor irrigated agricultural lands and a loss of a source of local school revenue for communities in close proximity to the reservoir
- Realignment of communities' economic base and changed potential for future growth

Many of the community-level impacts would be caused by the loss of irrigated agriculture on Ice Harbor Reservoir and increased grain transportation costs. Irrigated agriculture-related impacts could be minimized or partially eliminated by mitigation spending to modify existing irrigation pumps. Expanding rail capacity in the region or directly subsidizing affected farms would minimize potential impacts to those farms affected by increased transportation costs.

Communities would likely adjust to these changes. New individuals and businesses seeking new opportunities may replace those that have been displaced. Displaced human and capital resources may be employed in their next best use within the community. This type of adjustment does, however, take time and would vary by community. Community size has been identified as a critical factor affecting a community's ability to adapt to change, with smaller, less diverse communities tending to respond less favorably. The nine focus communities briefly addressed here are discussed in more detail in the DREW Social Analysis report (DREW Social Analysis Workgroup, 1999) and Technical Appendix I, Economics (Section 7.0).

5.13.2.2 Community Perceptions

The community-based social impact assessment conducted by the UI Team consisted of two phases. The first phase addressed 18 communities in the lower Snake River study area, including the 9 examined by the DREW Social Analysis Workgroup. The second phase involved nine community forums conducted upriver of the lower Snake

River study area in southern Idaho. These two phases are addressed in the following sections.

Phase I—Lower Snake River Study Area

The following section is drawn from the UI team's discussion of the environmental effects of each alternative by community type (Harris et al., 1999a). This analysis did not address Alternative 2—Maximum Transport of Juvenile Salmon, but the impacts associated with this alternative are likely to be similar to those perceived for Alternative 3—Major System Improvements for most communities.

Each community forum consisted of a set of interactive, structured group activities. Forum participants were assigned to facilitated tables and asked to assess the current or base case condition of their community in terms of four key dimensions: people, jobs and wealth, place, and vision and vitality. Information was then presented on the projected biological, economic, and physical changes associated with three major alternatives: existing conditions, major system improvements, and dam breaching. Community members were asked to forecast the likely effects of these actions on their community and rate changes across the four established community dimensions for 2020. Participants were asked to provide written justification for these ratings, which ranged from –5 ("adversely affected" by the alternative) to +5 ("beneficially affected") relative to existing conditions.

Perceptions of change in the four key dimensions of community are summarized for each alternative by community and community type in Table 5.13-8. Perceived impacts are addressed by community type and community in the following discussion.

Trade Center Community Type

Residents of Lewiston, Clarkston, and the Tri-Cities of Kennewick, Pasco, and Richland perceived rivers—particularly rivers with dams—as central to their community's character and way-of-life. The ports of Lewiston and Clarkston are viewed by residents as important facilitators of economic growth, with barging and shipping on the lower Snake River perceived as key factors in each community's economic development (although reportedly half of the shipping through the Port of Lewiston, for example, is by truck and rail). Recreational and scenic amenities associated with the existing reservoir system are also seen as important to the character of the area. The economy of the Tri-Cities differs from those of the other two towns because at present it is not directly related to the use of the river. Residents do, however, make use of existing upriver recreation facilities.

Forum participants in each of the four communities forecast an improvement across all four community dimensions by 2020 for Alternative 1—Existing Conditions (Table 5.13-8). Little change from this pattern was forecast for Alternative 3—Major System Improvements. Significantly adverse effects were, however, forecast under Alternative 4—Dam Breaching. These adverse effects included declining population, schools, and economic and civic vitality, as well as increased traffic congestion, business failure, and general pessimism.

In general, the results suggested less consensus among forum participants and a wider range of variability in perceived likely impacts for Lewiston than for Clarkston and the Tri-Cities. Ratings of perceived impacts under dam breaching were more negative in the Tri-Cities than they were in Lewiston. Residents of the Tri-Cities would mainly experience a loss in irrigated agriculture and upriver recreation opportunities. Under a dam breaching scenario, the Tri-Cities would likely experience greater positive economic effects than the Lewiston valley, with Pasco, in particular, becoming a transportation hub for commodity shipments formerly transported on the lower Snake River.

Highly Productive Dryland Agriculture Community Type

Residents of the traditionally stable, wealthier, but now-changing farming, bedroom, and government-based communities of the Highly Productive Dryland Agriculture Community Type perceived Alternative 1—Existing Conditions to mainly be an improvement across all four community dimensions (see Table 5.13-8). Conditions under Alternative 3—Major System Improvements were generally perceived about the same or more beneficial for most dimensions in most of the towns. People generally saw current trends continuing. Relatively minor changes perceived under Alternative 3 were increased utility rates and the short-term jobs that would result from efforts to modify the existing hydrosystem to recover salmon stocks.

Significantly adverse effects were perceived under Alternative 4—Dam Breaching. These effects included declining population, families, and schools; increased costs of business and living, decreased incomes and jobs, fewer businesses and decreased property values, a shrinking tax base, and reduced tax revenues (resulting in reduced public-sector budgets and services); and the loss of farm families and community pride and vitality. In addition, residents from these towns currently use the river for flatwater recreation activities.

If dam breaching were to occur, the increased costs of transportation for farmers in the Lower Snake River study area would be one of the major social impacts. Genesee, Idaho, for example, a community already in transition, would likely experience some of the greatest increases in transportation costs.

Productive Dryland Agriculture Community Type

These agriculture towns of eastern Washington have a significant relationship with the Snake River. An important aspect of this relationship is the transportation of agricultural products via the river at a comparatively low cost. These towns are located in relatively close proximity to the ports on the Columbia River. Increases in the costs of transporting commodities via the Columbia River System would therefore be less for these types of community than for the Highly Productive Dryland Agriculture Community Type.

Both Kahlotus and Washtucna saw some improvement in 2020 for the four community dimensions under Alternative 1—Existing Conditions (Table 5.13-8). The sense of community and vision and vitality is strong for these communities, but their economies, which continue to be agriculturally dependent, are perceived to remain poor despite being beneficially affected. Both communities see themselves

being beneficially affected by the Alternative 3—Major System Improvements, with benefits similar to those under Alternative 1—Existing Conditions.

Significantly adverse effects were perceived under Alternative 4—Dam Breaching. Justifications given by both communities were a perception of decreased job opportunities, increased utility rates, decreased tax base, poor roads and highways from increased trucking, as well as factors such as leadership decline and lack of recreation and tourism opportunities. Other adverse factors such as a decrease in Corps employment in Kahlotus may have also negatively influenced group ratings.

Multiple Natural Resource Use Community Type

The towns included under this community type are located upriver from the lower Snake River. As a result, their primary relationship with the lower Snake River pertains to the potential effects of the proposed alternatives upon the local fisheries in the Clearwater, Salmon, and Grand Ronde rivers.

Active and involved residents of some towns, like Orofino and Wieppe, shared the philosophies and concerns of farmers downriver from them with respect to Alternative 4—Dam Breaching (Table 5.13-8). In other communities such as Riggins and Enterprise, which have a tourism economy that is somewhat dependent on natural amenities, residents perceived that their community would decline or stay the same under Alternative 1—Existing Conditions. Riggins participants perceived all four community dimensions would improve under Alternative 4—Dam Breaching.

The Multiple Natural Resource Use Community Type perceived Alternative 4—Dam Breaching more positively than any of the other community types. The analysis of the impact rating justifications suggests that this is because these communities see themselves less directly connected to the commodity transportation issues of the lower Snake River and more influenced by salmon recovery. Salmon recovery would add to their nature-based tourism product mix, provide more fishing opportunities as well as enhancing their sense of place.

Snake River Irrigated Agriculture Community Type

The forum participants at Prescott saw Alternative 1—Existing Conditions and Alternative 3—Major System Improvements as equally beneficial across all four community dimensions. Alternative 4—Dam Breaching was, in turn, perceived as having negative effects across all four dimensions (Table 5.13-8).

Columbia River Agriculture Community Type

None of the communities in the Columbia River Agriculture Community Type have a direct relationship with the lower Snake River, but residents use it for recreation purposes as well as indirectly for the transportation of commodities through ports on the Columbia River. Their perceptions of the effects of the Alternative 4—Dam Breaching appeared to be influenced by a general mistrust of the Federal government and fear of a "domino effect" (i.e., "if it [dam breaching] happens on the lower Snake River, it won't be long before it happens on the Columbia River").

All communities rated Alternative 1—Existing Conditions and Alternative 3—Major System Improvements positively across all four community dimensions. All the communities, with the exception of Stanfield, generally saw themselves being adversely affected by Alternative 4—Dam Breaching. Adverse effects perceived by these communities include an increase in utility rates, a shrinking agricultural base, job losses from an agricultural decline, increased traffic congestion, higher taxes, loss of parks and open spaces, and decreased air and water quality.

Phase II—Southern Idaho

Nine community forums were conducted in southern Idaho. Three community types were identified: the trade center community (Boise and Twin Falls), the multiple natural resource use community (Ashton, Cascade, and Salmon), and the middle Snake River irrigated agricultural community (Firth, Hagerman, Homedale, and Rupert). The following sections summarize the findings for each community type. These findings are discussed in more detail in the Phase II Community-Based Social Impact Assessment (Harris et al., 1999b).

Trade Center Community Type

Forum participants in the Trade Center communities of Boise and Twin Falls in Phase II perceived positive impacts associated with the implementation of Alternative 4—Dam Breaching. Given the indirect nature of the relationship of these communities to the lower Snake River, their comparatively high capacity to respond to change, and the comparatively minimal degree and kind of impacts they would experience from the implementation of Alternative 4—Dam Breaching, risks associated with this alternative would be minimal for communities of this type compared to other community types.

Multiple Natural Resource Use Community Type

Forum participants in the Multiple Natural Resource Use communities perceived a range of potential impacts associated with the implementation of Alternative 4—Dam Breaching. These potential impacts ranged from somewhat beneficial to very adverse. Salmon, Idaho, although distant from the immediate lower Snake River study area, could be beneficially affected by increased salmon runs. As suggested by their identified impacts and the travel and tourism nature of their local economy, participants perceived some benefits from increased salmon runs and adverse impacts associated with declining salmon and steelhead runs under other alternatives. Similar results were found for Cascade, Idaho. Communities of the Multiple Natural-Resource Use Community Type tend to be relatively resilient and economically diverse, which indicates that they, too, would be less at-risk to changes resulting from the proposed alternatives. It should, however, be noted, that the residents of this type of town perceived that their community character—a key element in the viability and diversity of their economy—would be significantly adversely affected by Alternatives 1 through 3.

The perceptions of forum participants in Ashton in southeastern Idaho differed from those of participants in Salmon and Cascade. Participants in Ashton perceived

adverse impacts associated with the implementation of Alternative 4—Dam Breaching, such as increased transportation and utility costs and possible effects on the traditional forest industry of the area.

Given these communities' varied perceptions of the risks associated with Alternative 4—Dam Breaching, the mix of beneficial and adverse impacts, and their active, ongoing efforts to adapt and respond to socioeconomic changes, these types of communities should be able to respond to changes associated with this alternative. Given their distance from lower Snake River ports, negative impacts associated with changes in transportation are likely to be less significant for these communities than for agriculture-based communities located to the north. These Middle Snake River Irrigated Agriculture communities vary in their level of resiliency and economic diversity. Hagerman and Rupert are most at-risk in terms of community capacity, while Firth has been found to be more resilient but also has a less diverse economic base than even other farm communities. In contrast, Homedale has a broader, more sound economic base.

Middle Snake River Irrigated Agriculture Community Type

Participants in the forums held in Middle Snake River Irrigated Agriculture communities (Firth, Hagerman, Homedale, and Rupert) perceived substantial negative impacts associated with the implementation of Alternative 4—Dam Breaching.

5.13.3 Effects to Low Income and/or Minority Populations

This section provides information on minority groups that constitute a relatively small percentage of the study area population (see Section 4.14-11). The following discussion specifically addresses Native American tribal members and Hispanic farm workers and assesses whether these groups may experience a disproportionately high and adverse effect from selection of one or more of the alternatives being considered in this FR/EIS. Potential effects to tribal members are also discussed in Sections 4.8 and 5.7 (Native American Indians); Technical Appendix I, Economics; and the Tribal Circumstances and Perspectives report prepared by a private contractor in association with the Columbia River Inter Tribal Fisheries Commission (CRITFC) (Meyer Resources, 1999). The Tribal Circumstances and Perspectives report provides the perspective of the four CRITFC tribes—the Nez Perce, Yakama, Umatilla, and Warm Springs—and also addresses the Shoshone-Bannock tribes. These five tribes are referred to as the study tribes in the following discussion.

5.13.3.1 Alternatives 1 through 3

The implementation of any of the first three alternatives would not change the current circumstances of tribal members or Hispanic workers employed at farms irrigated from the Ice Harbor Reservoir in the short-run. However, as scientific data is collected and results are verified with regard to dam mortality and juvenile transportation, these alternatives could result in beneficial changes to the status quo.

Another view is expressed in the Tribal Circumstances and Perspectives report. This report considered three alternatives—Existing Conditions, Maximum Transport of Juvenile Salmon, and Dam Breaching—and concluded that the first two of these

alternatives would do "little or nothing" to correct the cumulative inequities that the tribes have suffered from construction and operation of the four lower Snake River dams. This analysis did not address Alternative 3—Major System Improvements, but the impacts associated with this alternative are likely to be similar to those for Alternative 2—Maximum Transport of Juvenile Salmon. The assessment presented in the Tribal Circumstances and Perspectives report addresses four generalized factors identified in an environmental justice guidance document produced by the EPA (EPA, 1998). Table 5.13-9 summarizes the relative effects of Alternatives 1 and 2 from the perspective of the five study tribes based on these four factors.

Table 5.13-9. Summary of Tribal Environmental Justice Effects Associated with Alternatives 1 and 2[1/]

Factor	Relative Effects on the Study Tribes
Income Level/Health Care Access	• Tribal families are impoverished and unemployed at 3 to 4 times the levels of Washington/Oregon/Idaho residents as a whole (Table 4.8-2). Wintertime tribal unemployment can reach 80 percent. • Tribal members are dying at rates that range from 20 percent to 130 percent higher than non-Indian residents. • Recent analyses describe tribal health and health care access as "poor." • Implementation of Alternatives 1 or 2 would have no substantial effect in remedying these adverse conditions—and if recovery estimates are too optimistic, could make them worse.
Life Support Resources	• Extensive information presented in the Tribal Circumstances and Perspectives report places salmon at the center of the study tribes' cultural, spiritual, and material world. This report argues that salmon guaranteed to the tribes by treaty have almost entirely been lost. Tribal spokespersons and health experts cited throughout the report have identified the devastating effect these losses have had on tribal culture, health, and material wellbeing. • Beatty et al. (1999) indicate that the lower Snake River dams have contributed substantially to destruction of these life-support resources. • Selection of Alternatives 1 or 2 would not significantly change these cumulative conditions—and the pain, suffering and premature deaths of tribal peoples would continue over future decades.
Economic Base	• The cumulative effects of dam construction have transferred potential wealth produced in the river basin from the salmon on which the tribes depend to electricity production, irrigation of agriculture, water transport services and waste disposal, these latter primarily benefiting non-Indians. These transfers have been a significant contributor to gross poverty, income and health disparities between the tribes and non-Indian neighbors. • Selection of Alternatives 1 or 2 would continue these conditions and disparities.
Inconsistent Standards	• Historically, agencies asserted confidence that they could manage uncertainty concerning adverse impacts on salmon during construction of the dams that facilitated wealth transfers from the tribes to non-Indians. Some of the same agencies now claim to be risk adverse, when considering more substantial remedial actions that would recover salmon and result in some measure of rebalancing of wealth to improve the circumstances of tribal peoples.

[1/] This analysis did not address Alternative 3—Major System Improvements, but the impacts associated with this alternative are likely to be similar to those for Alternative 2—Maximum Transport of Juvenile Salmon.

Source: Meyer Resources, 1999 (Table 56)

5.13.3.2 Alternative 4—Dam Breaching

Dam breaching could have significantly different effects on the two potentially affected minority groups considered here.

Tribal Members

If the assumption is made that dam breaching alone would increase the fish runs, the increased salmon under this alternative would benefit the tribes. The Tribal Circumstances and Perspectives report states that this alternative would allow significantly more tribal harvesting and processing, facilitate extended distribution of salmon as food through extended families and to elders, and expand the fundamental economic base of tribal well-being. Table 5.13-10, summarizes the relative effects of Alternatives—Dam Breaching from the perspective of the five study tribes based on the same four factors considered in Table 5.13-9.

Table 5.13-10. Summary of Tribal Environmental Justice Effects Associated with Alternative 4—Dam Breaching

Factor	Relative Effects on the Study Tribes
Income Level/ Health Care Access	• Alternative 4 would not be sufficient to fully restore tribal harvests to the levels obtained before the lower Snake River dams were built. Alternative 4 is the only option that would substantially improve opportunities for tribal fishing—adding 1.6 million pounds to tribal harvests within 30 years. Tribal spokespersons and experts cited in the Tribal Circumstances and Perspectives report inform us that as salmon recovery occurs, tribal health would improve, tribal incomes would increase, and the cultures of the five study tribes would be strengthened. • Cumulatively, as salmon recovery progressed, Alternative 4 could be expected to significantly reduce the differences between tribal and non-Indian material wellbeing (see Table 4.8-2).
Life Support Resources	• Despite severe damage to most stocks, salmon and water remain the central elements of tribal cultural, spiritual and material survival. Today, beset by a narrow on-reservation resource base, and still coping with racial prejudice and limited opportunity off-reservation, the tribes continue to first look to the salmon as they seek to build a more secure future. • Selection of Alternative 4 would significantly reverse a 144-year post-Treaty cumulative trend that, to date, has resulted in endangerment of the salmon, and consequently, endangerment of tribal peoples—while people as a whole in the region have prospered.
Economic Base	• Selection of Alternative 4 would provide significant restoration for salmon. The tribes have harvested and processed salmon from pre-contact times, and possess an economic comparative advantage respecting such activities. Alternative 4 would allow significantly more tribal harvesting and processing; would facilitate extended distribution of salmon as food through extended families and to elders; and would expand the fundamental economic base for tribal wellbeing. • The positive economic effects discussed here would be expected, over time, to significantly reduce the differentials in poverty and unemployment levels between tribal members and their non-Indian neighbors.
Inconsistent Standards	• Selection of Alternative 4 would reverse more than a century of cumulative regional takings of the Treaty-protected resources of the tribes–and provide a step toward more equitable sharing of potential wealth from the Columbia/Snake River Basin between tribal and non-tribal peoples.

Source: Meyer Resources, 1999 (Table 56)

While the Tribes' study concludes there are adverse environmental justice effects associated with each of the alternatives, the Corps concludes that any alternative that brings more salmon back to the Snake River would benefit the Tribes.

Irrigated Agriculture Farm Workers

Alternative 4—Dam Breaching could indirectly affect farm workers located throughout eastern Washington, in the upriver subregion, and as far as North Dakota. Grain shipments dominate downriver commodity movements on the lower Snake River and farm workers could be indirectly affected by potential increases in transportation costs. Alternative 4—Dam Breaching could also directly affect those workers employed on the farms currently irrigated from Ice Harbor Reservoir (see Section 5.10, Agricultural, Municipal, and Industrial Water Uses). Twelve farm operations account for 32,618 of the approximately 37,000 acres irrigated from Ice Harbor Reservoir. A total of 2,973 employees—812 full-time and 2,161 seasonal and part-time—worked at these farms during 1997 (Table 5.13-11). It is not clear whether all of the identified seasonal workers are employed annually or just for special projects such as planting trees, harvesting, and pruning. These employment numbers apply to the entire acreage of each surveyed farm and not just the portion irrigated from Ice Harbor Reservoir. Approximate Ice Harbor irrigation-related employment numbers are presented in Table 5.13-11.

Table 5.13-11. Employment and Acreage on Farms Irrigated from Ice Harbor Reservoir

						Estimated Irrigation-related Employment		
County	Total Farm Acreage	Total Employment Full-time	Total Employment Part-time	Seasonal Part-time	% of Acres Irrigated from Ice Harbor[1/]	Full-time	Part-time	Seasonal Part-time
Walla Walla	34,900	156	89	822	79.5	124	71	653
Franklin	7,117	656	0	1,250	67.7	444	0	846
Total	**42,017**	**812**	**89**	**2,072**	**77.5**	**629**	**69**	**1,606**

1/ On-site wells irrigate the majority of the remaining acres.
Source: DREW Water Supply Workgroup, 1997/1998 (Farm Survey)

The DREW Water Supply Workgroup used two approaches—the pump modification approach and the farmland value approach—to estimate the economic effects of Alternative 4—Dam Breaching on Ice Harbor irrigators. This analysis indicated that the cost of modifying the Ice Harbor agricultural pumping stations would be more than twice the value of the 37,000 acres irrigated from Ice Harbor (see Section 5.10, Agricultural, Municipal, and Industrial Water Uses). In the absence of Congressional appropriation, costs to modify the pumps could be prohibitive based on total farm values.

Unemployment compensation data suggest that about 84 percent of farmworkers employed in the production of crops are Hispanic (Wahlers, 1998). While these figures are only for those farm workers who filed unemployment claims, Wahlers

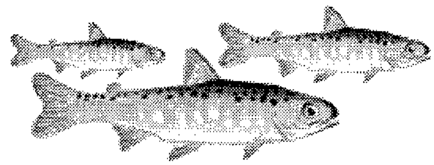
(1998) suggests they are likely representative of all hired agricultural workers. Contacts made with the Yakima and Olympia Washington State Employment Security offices also suggest this. Direct contact with one of the larger potentially affected farms also suggested that this is the case. The Labor Services Manager of this farm estimated that people of Hispanic origin may account for as many as 90 percent of the full-time, part-time, and seasonal labor force employed at their farm and other surrounding farms.

Based on this data, a total of 1,935 to 2,074 workers of Hispanic origin could be affected by dam breaching (Table 5.13-12). This represents from 4.5 to 4.8 percent of the 1990 study area population that identified as Hispanic and from 8.8 percent to 9.5 percent of the 1990 reservoir subregion population that identified as Hispanic. At a county level, this represents from 15.2 to 16.3 percent of the total 1990 Hispanic population in Walla Walla County and from 9.5 to 10.2 percent of the total Hispanic population in Franklin County.

Table 5.13-12. Estimated Hispanic Labor Force on Farms Irrigated from Ice Harbor Reservoir

County	Full-time	Part-time	Seasonal Part-time	Total Employment
Walla Walla	124	71	653	848
84 Percent Hispanic	104	59	549	713
90 Percent Hispanic	112	64	588	763
Franklin	444	0	846	1,290
84 Percent Hispanic	373	0	711	1,084
90 Percent Hispanic	400	0	762	1,161
Total	**629**	**69**	**1,606**	**2,304**
84 Percent Hispanic	529	58	1,349	1,935
90 Percent Hispanic	566	62	1,445	2,074

Based on this information, it appears that if these farms were to go out of business, persons of Hispanic origin would be disproportionately affected.



5.14 Aesthetics

Reservoir operations can have significant aesthetic impacts on adjacent lands. These impacts result from a number of factors, including increased shoreline visibility and contrast, erosion, changes in recreational facilities, changes in water characteristics, and production of dust and odors. Decreases in aesthetic quality can affect recreational use and have social and economic consequences for visitors and residents.

This section discusses the likely short-term and long-term aesthetic effects associated with the four alternatives. Short-term effects are associated with drawdown activities and newly exposed sediments. Long-term effects are those that occur after systems have stabilized. In general, most of the discussion is focused on Alternative 4—Dam Breaching because little or no change in aesthetics would be expected as a result of the first three alternatives. See Table 5.14-1 for a summary of potential effects on aesthetics.

5.14.1 Aesthetic Impact Issues

Generally, changes in the aesthetic qualities of reservoirs and river reaches can be attributed to changes in specific physical factors. These factors, discussed below, occur with reservoir drafting (the release of water from storage areas) and could occur under dam breaching conditions.

Table 5.14-1. Summary of the Potential Effects of the Alternatives on Aesthetics

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Physical Factors	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• In the short-term, the river shoreline with bare river bottom would be visually unappealing, but after about 3 years, the shoreline would acquire an appealing, natural look. • Increased noise in the short-term from deconstruction activities and in the long-term from increased rail and truck traffic due to loss of barging.
Effects on Viewers	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• Initial increase in viewers interested in deconstruction. • Short-term decrease in viewers due to reduction in attractiveness and because attractions of interest would no longer be functioning. • Long-term stabilization or increase in viewers due to free-flowing riverine character. • Presence of remaining dam structures could be unappealing to viewers.

5.14.1.1 Shoreline Contrast

Shoreline contrast is an important visual element when there is substantial shoreline exposed due to lower reservoir levels and contrast between shoreline and adjacent uplands. The aesthetic impact of reservoir drawdown depends on the amount of shoreline exposed, the color and textural contrast between shoreline and adjacent uplands, and the number of people viewing the affected shorelines. If there is an opportunity for large numbers of people to view an exposed area, then there is a high potential for visual impact.

5.14.1.2 Erosion

Fluctuating reservoir levels can cause erosion and landslides along reservoir shores. Scarring from erosion and landslides intensifies shoreline contrast and makes landscapes unattractive. Erosion is generally less of an aesthetic concern on free-flowing river reaches, where dynamic natural processes are expected.

5.14.1.3 Seep Lakes and Embayments

Reservoir drawdown could make seep lakes and embayments susceptible to possible drying and loss of flushing action.

5.14.1.4 Water Characteristics

Changes in reservoir levels can affect the physical and visual characteristics of water in several ways. When water levels in reservoirs are lowered, the remaining water flows at a higher velocity and picks up additional sediment, which in turn leads to increased turbidity. Erosion of reservoir sediments exposed by drafting has the same effect. Increases in turbidity can decrease water clarity and change its color.

The quantity of water in a river can affect its aesthetic quality. Different viewers have different perceptions about the relationship between quantity of river flow and the aesthetic quality of the river environment. Flows similar to historic flows would be acceptable to many viewers.

5.14.1.5 Waterside Facilities

Reservoir drafting can expose waterside facilities such as beaches, swimming areas, boat ramps, docks, and marinas, leaving them unusable (impacts to recreation facilities are discussed in Section 5.12, Recreation). These abandoned and non-functional facilities can be unsightly and detract from the look and feel of a natural (i.e., free-flowing) river environment. Some recreation facilities depend on irrigation for park landscaping. Operating reservoirs at elevations below irrigation intakes could reduce or eliminate the ability to irrigate lawns and plantings. The aesthetic quality of these facilities would be diminished by withered or dead landscaping.

5.14.1.6 Dust and Odors

Reservoir drawdown exposes shorelines and lake bottoms to the effects of wind. Fine sediments dry out and are carried off by the wind, which can be a nuisance to nearby residents and recreationists. Odors can be created in areas where organic material is exposed as the result of drafting. Any dust or odor would only last one or two years following transmission.

5.14.2 The Alternatives and their Impacts

5.14.2.1 Alternative 1—Existing Conditions

Under Alternative 1—Existing Conditions, the four hydropower facilities on the lower Snake River would continue to operate as originally designed. No impacts to aesthetics are expected under this alternative.

5.14.2.2 Alternative 2—Maximum Transport of Juvenile Salmon

Under this alternative, operation of the four dams would continue as it would under Alternative 1—Existing Conditions. Therefore, no impacts to aesthetics are expected under this alternative.

5.14.2.3 Alternative 3—Major System Improvements

Under this alternative, operation of the four dams would continue as it would under Alternative 1—Existing Conditions. Therefore, no impacts to aesthetics are expected under this alternative.

5.14.2.4 Alternative 4—Dam Breaching

Under this alternative, the four dams would be breached and the lower Snake River would be free-flowing. Aesthetic impacts could result from the physical factors discussed previously. Most of these impacts would be short-term and would subside after the river and shorelines stabilize. Figure 5.14-1 is a photograph of the existing Lower Granite Dam. It is representative of the first three alternatives (i.e., existing conditions). Figure 5.14-2 is a photograph that shows the site condition during construction of Lower Granite Dam that may be similar to the condition following implementation of Alternative 4—Dam Breaching.

Physical Factors

A total of approximately 14,000 acres of reservoir bottom would be exposed following the return of the 140-mile river stretch to a free-flowing condition. Surface areas of current reservoirs and acres of exposed reservoir bottom under typical river flow conditions following dam breaching are presented in Table 5.14-2.

Implementation of Alternative 4—Dam Breaching would dramatically change the appearance of the river and its shoreline. Average surface water levels could drop from between 94 feet below minimum operating pool (MOP) at Ice Harbor to 110 feet below MOP at Lower Granite. These are, however, maximum values. The drop at the upper reservoirs could also be as little as 10 feet. The lake-like appearance of each reservoir would be replaced by a view of free-flowing water which would be riverine in character.

Following drawdown, the river's shoreline would be void of vegetation. Much of the existing shoreline riparian vegetation would be lost and subsequently converted to upland habitat. A Reservoir Revegetation Plan would be implemented to accelerate the development of native vegetation and control soil erosion due to wind and rain (see Annex K of Technical Appendix D, Natural River Drawdown Engineering). The approximately 14,000 acres of exposed reservoir bottom would be bare substrate, mainly silt and sand. In the short-term (1 to 3 years), this area would be visually unappealing. In the long-term (greater than 3 years), the shoreline would acquire a natural look. Historical acreages of riparian habitat along the lower Snake River suggest that breaching of the dams could result in a long-term increase in riparian vegetation along the river.

Another aesthetic effect of Alternative 4—Dam Breaching would be increased noise. In the short-term, construction-related activities would be heard by people in the vicinity of each dam. Noise would be generated by concrete drilling and blasting equipment, vehicles used to haul materials, and other sources. The use of helicopters to implement the Reservoir Revegetation Plan would also contribute to short-term noise. In the long-term, additional noise would be generated by trucks and trains whose number of trips would increase to replace barge transportation.

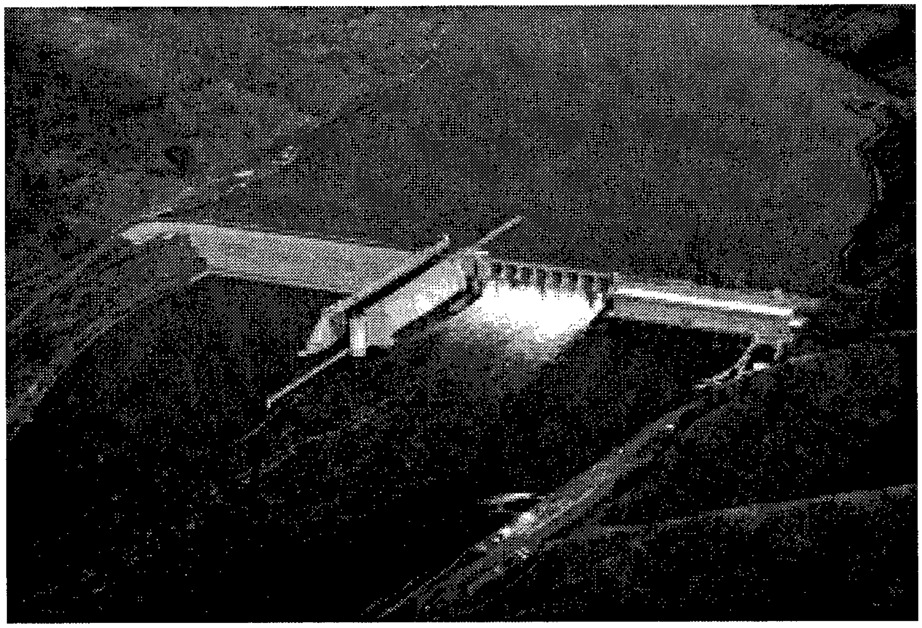


Figure 5.14-1. Current Photograph of the Lower Granite Dam Representative of the First Three Alternatives

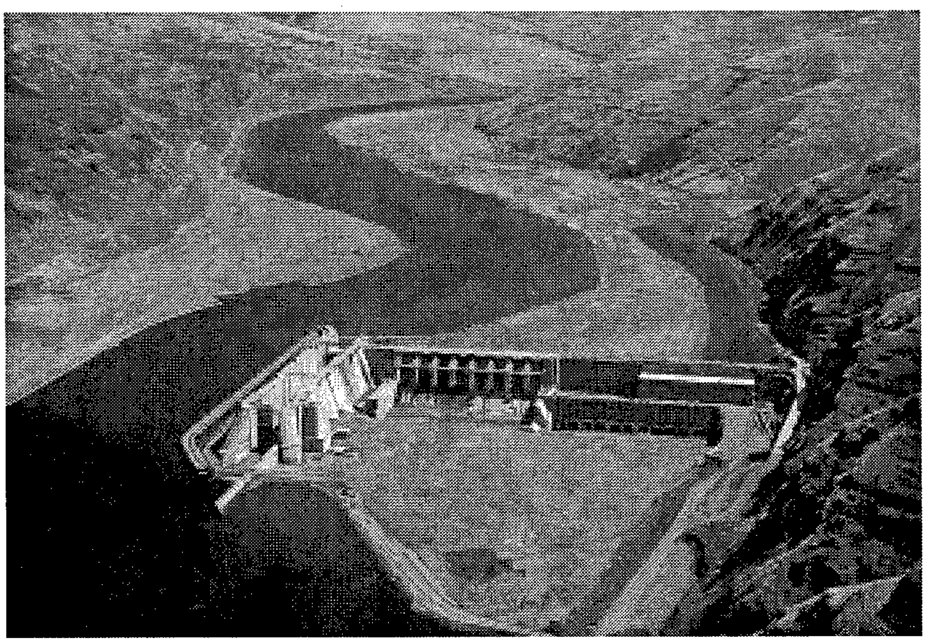


Figure 5.14-2. Site Condition During Construction of Lower Granite Dam That May Be Similar to the Breached Condition

Table 5.14-2. Areas of Current Reservoirs and Exposed Reservoir Bottom

Reservoir	Area of Current Reservoir (acres)	Exposed Reservoir Bottom (acres)
Ice Harbor to Lower Monumental	9,001.8	3,879.8
Lower Monumental to Little Goose	4,960.4	1,443.4
Little Goose to Lower Granite	10,825.2	5,640.2
Lower Granite to the Clearwater River at Asotin	8,448.2	2,808.2
Total	**33,235.6**	**13,771.6**

Source: Battelle, 1999

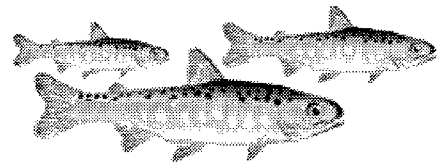
There would also be additional noise associated with the free-flowing river than with the current reservoir system. There would, however, no longer be noise associated with operation of the four lower Snake River hydroelectric generating facilities.

Effects on Viewers

Initially, the demolition of the four dams could attract visitors who would be interested in viewing the scene; but, in general and over the longer term, viewer numbers would be considerably less than under current conditions (Corps and NMFS, 1994). Fewer visitors would be drawn specifically to the dams because navigation locks, fish facilities, and other attractions of interest would no longer be functioning.

The main visual impact would be replacement of the current lake views with views of vegetated uplands, riparian areas, and occasional glimpses of the river. Viewers from several specific areas would be more affected by visual changes than others. For example, those Clarkston and Lewiston residents whose homes overlook the river would be exposed daily to views of the drawdown until the exposed areas have revegetated. Highway travelers along U.S. 12 and other routes that follow or overlook the river would see mudflats and shoreline contrast due to dam breaching until the exposed areas were revegetated. Finally, those recreationists who visit areas near the river would see the affected lakebed areas. This group includes picnickers and trail users at Swallows Park and along the Lewiston Levee Greenbelt.

Loss of the current reservoirs may be regarded as an unavoidable adverse aesthetic impact by certain groups of viewers. For others, the long-term aesthetic impacts of Alternative 4—Dam Breaching could be positive. Over a period of several years, the river and shoreline would stabilize and become more aesthetically appealing because of features such as vegetation and beaches. Many viewers would appreciate the free-flowing character of the river and its return to its historic state. However, the remaining structures at the four dam sites (e.g., powerhouses, navigation locks) and disturbed work areas (e.g., disposal sites) would be clearly visible along some river reaches.



5.15 Economic Overview

Actions taken to improve fish passage and survival along the lower Snake River could have economic and social effects on local communities, the Snake River region, the Pacific Northwest, and the nation, as a whole. The economic effects of actions related to the lower Snake River have been analyzed by numerous entities throughout the region. To reduce conflicting analyses and pool resources for a more efficient effort, the Corps convened DREW to develop a combined economic analysis. Members of DREW include representatives of various Federal and regional agencies, tribal representatives, and other interested parties.

DREW conducted the necessary technical analyses to assess the potential economic and social effects of the four alternatives. Areas of analysis included power, water supply, recreation, transportation, and tribal circumstances. The results of these analyses are summarized, as appropriate, by resource area in Sections 5.1 through 5.14. The final economic and social analysis presented in Technical Appendix I, Economics addresses potential economic and social effects at three geographic scales—national, regional, and local. The structure of this analysis is based upon the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* developed by the U.S. Water Resources Council (WRC) (WRC, 1983). National and regional effects are addressed in separate accounting stances under these guidelines. The National Economic Development (NED) account displays changes in the economic value of the national output of goods and services, while the Regional Economic Development (RED) account addresses changes in the distribution of regional economic activity.

Local effects—specifically those to potentially affected local communities and Native American tribes—are addressed under separate accounts. Potential impacts upon regional jobs and income, local communities, and Native Americans are discussed in Sections 5.13 and 5.7 (Social Resources and Native American Indians, respectively). The purpose of this section is to provide an overview of the findings of the NED analysis. This analysis and its findings are discussed in considerably more detail in Technical Appendix I, Economics. Another area of analysis briefly summarized here

is the passive use value analysis developed for this study by the DREW Recreation Workgroup.

5.15.1 National Economic Development

NED costs and benefits are the decrease or increase in the value of the national output of goods and services expressed in dollars. NED figures reflect costs and benefits to the nation and not to a particular region. The NED analysis conducted for this study addresses power, recreation, transportation, water supply, commercial fishing, tribal circumstances, flood control, and implementation/avoided costs (Table 5.15-1). There are no dollar figures associated with the tribal circumstances or flood control components of this analysis. NED benefits associated with increased tribal commercial harvest are included in the commercial fishing totals.

NED costs are:

- Implementation costs for fish-related improvements
- Cost increases associated with the shift from hydropower to more expensive forms of replacement power
- Transportation cost increases associated with the shift of barge-transported commodities to more costly truck and rail systems
- Costs incurred as result of impacts to users presently withdrawing water from the lower Snake River reservoirs.

NED benefits are:

- Costs incurred under Alternative 1—Existing Consitions that would be avoided under the other alternatives. These include operations, maintenance, repair, and replacement costs and the costs associated with the rehabilitation of existing infrastructure.
- Recreation benefits from increased fish runs and the shift to a free-flowing river.
- Commercial fishing benefits from increased fish runs.

5.15.2 Passive Use Values

This section presents a summary of the passive use values for salmon recovery and survival and for the creation of a free-flowing river. This analysis is discussed in more detail in Technical Appendix I, Economics (Section 4.0). Economists generally recognize that there is a benefit associated with knowing that the resource exists even if no use is made of it. There are, however, disagreements about how to measure passive use values. The passive use analysis presented in Technical Appendix I, Economics used a benefit transfer approach. It should be noted that passive use values are not NED benefits.

Table 5.15-1. Summary of Average Annual NED Costs/Benefits ($1,000s of dollars)

Costs and Benefits[1/]	Alternative 2[2/ 3/]	Alternative 3[2/ 3/]	Alternative 4[2/ 3/]
Costs			
Implementation Costs	-	(5,931)	(48,787)
Power	-	-	(271,000)
Transportation	-	-	(24,034)
Irrigation/Water Systems	-	-	(15,424)
Total Costs	-	*(5,931)*	*(359,245)*
Benefits			
Avoided Costs	-	-	29,178
Recreation	2,030	2,080	82,000
Commercial Fishing[4/]	160	161	1,593
Implementation Costs	3,457	-	-
Power	8,500	8,500	-
Total Benefits	*14,147*	*12,982*	*112,771*
Total Costs - Benefits	**14,147**	**4,810**	**(246,474)**

1/ These costs and benefits, calculated for a 100-year period of study extending from 2005 to 2104, are discounted using a 6.875 percent discount rate and converted to 1998 dollars.

2/ Costs and benefits are presented for Alternatives 2 through 4 net of the base case (Alternative 1).

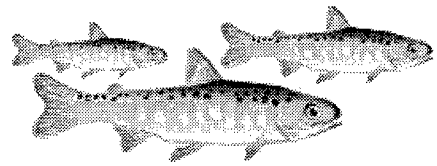
3/ A positive monetary value indicates that the alternative has a lower cost or greater benefit than Alternative 1. A negative monetary value indicates that the alternative has a higher cost or less benefit than Alternative 1. Positive monetary values, therefore, represent benefits, while negative values represent costs.

4/ A small portion of the commercial fishing benefits consist of ocean recreation fishing.

The passive use value estimates for salmon were calculated on a per fish basis based on the preliminary PATH results, as extended by the DREW Anadromous Fish Workgroup. Values were calculated for Alternatives 2 through 4 net of Alternative 1—Existing Conditions.

Using the 1998 model results, the average annual return of wild salmon is less under Alternatives 2 and 3 than under Alternative 1—Existing Conditions. This resulted in negative passive use values for these alternatives. The passive use value associated with Alternative 4—Dam Breaching was estimated to range from $66 million to $879 million per year, with a middle range between $142 and $508 million per year. The passive use value of a free flowing lower Snake River was estimated at $420 million per year.

Using the 1999 model results would reduce the difference between Alternatives 1 through 3 and Alternative 4—Dam Breaching. This would lower the estimated passive use value for Alternative 4—Dam Breaching, which, as noted above, is calculated net of Alternative 1—Existing Conditions. However, the passive use values associated with the free flowing river would not change.



5.16 Cumulative Effects

The National Environmental Policy Act (NEPA) and the Council on Environmental Quality (CEQ) regulations require Federal agencies to consider the cumulative impacts of their actions. Cumulative impacts are defined as the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions, regardless of what other agency or person undertakes the other actions. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time (40 CFR 1506.7).

Assessment of potential cumulative impacts for the FR/EIS alternatives involves two dimensions. One dimension relates to the accumulation of localized or project-specific effects from the actions for the entire river system. The results reported in Section 5.0 for many of the resource areas identify a number of discrete impacts at specific locations or river reaches. In some cases, these individual or localized impacts are not significant, but the aggregate effect over the entire system may be significant. (Conversely, in some cases, there are considerable changes in multiple locations that tend to balance out at a system-wide level.) Therefore, one level of cumulative impact analysis is already contained in the results for the various resource or subject areas in Section 5.0, Environmental Effects of Alternatives.

The second dimension for cumulative assessment relates to the effects of alternatives within the context of other actions that have been affecting or will affect the same system resources. It is difficult to determine this context with any precision, particularly with respect to reasonably foreseeable future actions. Nevertheless, the following summary observations attempt to identify the likely cumulative context of the expected effects for each resource area:

- **Earth Resources**—Erosion caused by reservoir operations will add to sediment contributions from other activities in the basin. It is unknown whether sediment from these other sources will increase or decrease significantly in the future.

- **Water Quality**—Land use practices elsewhere in the Snake River Basin affect water temperature conditions in the river system. It is not known whether these activities will tend to increase or decrease temperatures. While natural sources can cause dissolved gas supersaturation, falling water at river system dams appears to be the primary source of this water quality problem.
- **Air Quality**—Blowing dust generated from exposed reservoir sediments will add to ambient dust from other sources, primarily agriculture and unpaved roads. It is possible that more dust from selected projects could combine with existing ambient levels to cause increased exceedances of air quality standards for particulates in highly localized areas.
- **Anadromous Fish**—River system operations, along with many other sources, have contributed to the historical declines in anadromous fish populations. In the future, however, it is likely that the general direction of change will be positive as recovery measures involving habitat, harvest, and hatchery operations are undertaken. Fish survival benefits associated with implementation of an alternative should add to improvements in other areas, resulting in higher long-term population levels.
- **Resident Fish**—The effects of the alternative actions on resident fish take place within the context of potential changes in sport fishing pressure, water quality, and management of other aquatic species, among other factors. Section 5.4.2, Resident Fish, identifies pertinent effects based on existing conditions that include changes as a result of other actions.
- **Wildlife**—The loss of wildlife habitat throughout the region as a result of development and habitat conversion has been widely noted. Consequently, wildlife habitat within the system that can be protected and maintained will take on increasing regional significance, and any loss of this habitat through operational changes would be cumulative.
- **Cultural Resources**—The situation for cultural resources is similar to that of wildlife. The continued loss and degradation of cultural resources in other areas increases the significance of those resources that can be protected and maintained.
- **Aesthetics**—The visual environment of all of the lower Snake River facilities has been modified to varying degrees by human activities. The immediate effects of dam breaching would diminish visual quality and would therefore have cumulative effects for the region, although it appears the long-term change would be small. Some people may find the change interesting, and thus it could be perceived as a positive change for those interested in viewing a restoration project.
- **Recreation**—If the supply of recreation opportunities does not keep pace with population growth and demand, the relative significance of the recreation opportunities provided by the river system will increase in the future.
- **Navigation**—Trends that would change the context of potential navigation impacts have been identified and incorporated in the transportation study (see Technical Appendix I, Economics).

- **Power**—Power supply costs and electric rates have increased in recent years as a result of several factors, including drought and the Bonneville Power Administration's (BPA's) debt repayment obligations. Cost and rate impacts associated with the alternatives would add to the level of financial strain on the regional electric system and ratepayers.
- **Irrigation**—Impacts on irrigators due to dam breaching are described in Section 5.10, Agriculture, Municipal, and Industrial Water Uses. In addition to those effects, irrigation pumping operations are also relatively sensitive to energy prices and can be adversely affected by electric rate increases.
- **Economic and Social Effects**—Some of the adverse economic effects associated with the alternatives would be region-wide, while others would tend to be concentrated in selected rural areas. Some of the communities likely to be affected have been experiencing long-term economic stagnation or declines through job and income losses in traditional resource-based industries. The cumulative effects of additional cost or employment impacts in these areas could be significant. Both Hispanic and tribal people might be disproportionately affected by dam breaching and these effects. Tribal peoples would likely benefit from any alternative that assists in salmon recovery while Hispanics may have more economic hardships if jobs are lost in those sectors dominated by them.

Several reasonably foreseeable future major actions have been identified in the Snake River and Columbia River basins may add to cumulative effects from the alternatives to the lower Snake River dams. Representative actions include: Snake River Flow Augmentation (an additional 1 million acre-feet [MAF] flow augmentation from the middle and upper Snake River basins), Interior Columbia Basin Eastside Ecosystem Management Project, Hells Canyon Relicensing Project, and the Nez Perce Tribal Hatchery Program. The latter project is the only project that has been implemented. The other projects have only been studied. While the 1 MAF flow augmentation project is not necessarily a reasonably forseeable action, it is representative of the tradeoffs future changes in flow augmentation may have. The following subsections summarize the projects that may adversely and/or beneficially affect the proposed alternatives for the lower Snake River.

5.16.1 Snake River Flow Augmentation Analysis

An option to provide an additional MAF of water for flow augmentation from the Snake River basin was considered during this study; but a fully developed alternative was not formulated and this option is not considered further in this analysis.

Based upon initial study findings, the MAF option did not meet Federal criteria for completeness and public acceptability and it is not considered further in this analysis. Some background information concerning the 1 MAF analysis follows.

The 1995 Biological Opinion called on the BOR to provide 427,000 acre-feet of water for flow augmentation by acquiring water supplies from willing sellers in the middle and upper Snake River basin. BOR has provided these flows each year by

leasing or acquiring water supplies and by releasing water from uncontracted storage space in BOR-owned reservoirs.

In 1997, the Columbia River Intertribal Fish Commission (CRITFC) asked the Corps to consider additional flow augmentation (beyond the 427,000 augmentation) be considered as an alternative in the Lower Snake River Juvenile Salmon Migration Feasibility Study (Feasibility Study). The Implementation Team also asked the Corps to consider providing an additional 1 MAF in its Feasibility Study. Based on these requests, the Corps asked BOR to analyze the local impacts from providing an additional 1 MAF for flow augmentation. In 1997, BOR initiated the requested investigation. Findings of the 1 MAF analysis were provided to the Corps in the *Snake River Flow Augmentation Impact Analysis Appendix* dated February 1999.

The appendix summarizes study findings which focus upon 1) two identified methods that might be considered to provide additional flows of 1 MAF from the Snake River system, and 2) estimated water acquisition costs and secondary economic and social impacts associated with those methods.

Acquiring a total 1.427 MAF from the Snake River Basin was analyzed conceptually—without specifying which water resources would be acquired due to uncertainty about quantifying acquisitions from the several Snake River tributaries and subbasins. The analysis did provide, however, some fundamental certainties:

- BOR does not have sufficient storage space in its exclusive control to provide the requested volume of water without significant impacts to water quality, resident fish and wildlife, and recreation.
- There are no sources of water in the Snake River Basin that are obvious candidates for reallocation. Within any scenario, some water users could be severely impacted while others could remain relatively untouched. Users with wide-ranging interests could be expected to vehemently oppose any effort to reallocate water from the local source.
- It is not possible to provide a total 1.427 MAF without reallocating existing irrigation water rights and/or contract entitlements.
- If irrigation bears the primary burden for providing a total 1.427 MAF (thus protecting water quality, resident fish and wildlife, and recreation), the annual economic impact to the region is estimated to range from $76 to $130 million. Total annual acquisition costs from willing sellers could exceed $80 million.
- If irrigation is protected—and instead water quality, resident fish and wildlife, and recreation bear the primary burden for providing 1.427 MAF by maximizing annual reservoir drawdowns— the annual economic impact to the region's irrigation economy is estimated to range from $44 to $95 million. Total annual acquisition costs from willing sellers under this scenario could exceed $57 million.

With either of the evaluated scenarios, affected water interests would strenuously resist a call for this level of flow augmentation. Although various methods could be used to acquire significant volumes of water, virtually all would involve litigation,

and may require congressional action to amend existing Federal BOR law and to appropriate the considerable level of funds required for water user compensation.

In summary, although a preliminary analysis of the 1 MAF option was evaluated in this study, great uncertainty and risk remains due the difficulty at this level of analysis of specifying where water for augmentation would be obtained, predicting the likelihood of overcoming institutional constraints associated with acquiring that quantity of water, and the high level of predicted economic and social impacts. Further, data to assess the biological benefits of additional flow augmentation was not developed by the Plan for Analyzing the Testing Hypotheses (PATH); consequently, an alternative could not be formulated in sufficient detail to compare the relative benefits and costs of a 1 MAF alternative to the other alternatives developed for this FR/EIS.

5.16.2 Interior Columbia Basin Ecosystem Management Project

The Interior Columbia Basin Ecosystem Management Project (ICBEMP) was initiated to:

- Identify existing or emerging resource problems that transcend jurisdictional boundaries, such as forest health problems and declining salmon populations, that can be addressed at a large scale
- Develop management strategies using a comprehensive "big picture" approach, and disclose interrelated actions and cumulative effects using scientific methods in an open public process
- Address certain large-scale issues such as species viability and biodiversity from a larger context using an inter-agency team
- Respond to President Clinton's July 1993 direction to develop a scientifically sound ecosystem based management strategy for lands administered by the Bureau of Land Management (BLM) or Forest Service in the upper Columbia Basin
- Replace interim management strategies with a consistent long-term management strategy.

In response, management direction for Forest Service- and BLM-administered lands across parts of seven states in the Pacific Northwest was re-examined and two draft EISs were prepared for different portions of the area covered by the ICBEMP. The project area for the upper Columbia River Basin includes 45 million acres of lands administered by the BLM or Forest Service in parts of Idaho, western Montana and Wyoming, and northern Nevada and Utah that are drained by the Columbia River System. The planning area for the Eastside EIS includes 30 million acres of lands administered by the BLM or Forest Service in the interior Columbia River Basin, upper Klamath Basin, and northern Great Basin that lie east of the crest of the Cascade Range in Oregon and Washington.

The two factors that underlie all of the management strategies of the alternatives selected for evaluation include: 1) ecosystem restoration, and 2) economic

sustainability for people and communities dependent upon resources from Forest Service- and BLM-administered lands.

The final implemented management strategy that could cumulatively affect the Lower Snake River Project would likely involve riparian restoration that over time may improve the fish habitat on Federally administered lands in the Snake River watershed. High quality habitat alone could increase abundance of individual fish, but would not likely reverse current negative population trends in the short-term.

5.16.3 Hells Canyon Relicensing Project

The Hells Canyon Relicensing Project is a series of efforts and studies required by the Federal Energy Regulatory Commission (FERC) to relicense operating hydroelectric projects. The Hells Canyon Project is operated by Idaho Power and consists of three developments or dams, reservoirs, and hydroelectric facilities: 1) Brownlee Development, 2) Oxbow Development, and 3) Hells Canyon Development. The numerous studies include aquatic, wildlife, botanical, historical and archaeological, and aesthetic studies. The results of the studies may change the operations on the project which may have adverse or beneficial effects to the lower Snake River. Information from the studies will be used to develop a new license application that will be submitted to FERC in 2003. The current license for the Hells Canyon Dam expires in 2005. It is not known what environmental enhancement measures or operational changes will be implemented at the Hells Canyon Dam, but if enhancements and operation measures help to increase the survival of fish or increase habitat availability for fish and wildlife, these changes would contribute beneficially to the recovery of salmon in the lower Snake River.

5.16.4 Nez Perce Tribal Hatchery Program

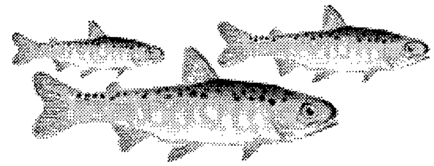
The Nez Perce Tribal Hatchery program is a salmon supplementation program that uses techniques compatible with existing aquatic and riparian ecosystems that would rear and release spring and fall chinook salmon, biologically similar to wild fish, to reproduce in the Clearwater Subbasin. The purposes of the program include:

- Protection, mitigation, and enhancement of Columbia River Basin anadromous fish resources, and development and reintroduction of natural spawning populations of salmon within the Clearwater Subbasin
- Long-term harvest opportunities for tribal and non-tribal anglers within Nez Perce treaty lands within four salmon generations (20 years) following project completion
- Sustainable long-term fitness and genetic integrity of targeted fish populations
- Acceptable limits of ecological and genetic impacts to non-targeted fish populations
- Promotion of Nez Perce tribal management of tribal hatchery facilities and production areas within Nez Perce treaty lands.

The multi-million dollar Nez Perce Tribal Hatchery project is in the final design stage and is nearly ready for review and approval as to whether it will shift into

construction and production. The hatchery as planned will actually consist of 2 central incubation and rearing facilities, 6 satellite rearing facilities, and 11 temporary weir sites. Maximum production goals are 768,000 spring chinook and nearly 3 million fall chinook juveniles, although initial production will be far below the maximum. NMFS completed a Biological Opinion in 1997 for Nez Perce Tribal Hatchery operations in 1998-2002. The Nez Perce tribe is also working on a project to restore coho to the Clearwater River, with initial funding provided by the Bureau of Indian Affairs for the release of approximately one million coho juveniles, taken from lower Columbia hatcheries and reared at existing facilities in the Clearwater River. The Clearwater River has also been a focus watershed for habitat improvements under the Northwest Power Planning Council's program, which the artificial production programs are intended to be linked.

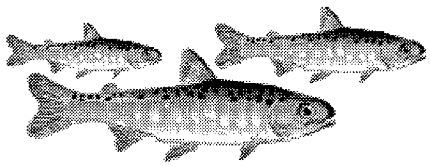
Based on BPA conclusions and the NMFS Biological Opinions, this project would not likely adversely affect listed salmon on the Snake River. The hatchery program would have little or no adverse impact to fish mortality of listed fish, and would not interfere with other recovery actions or otherwise impede the recovery of spring/summer chinook and sockeye salmon (BPA et al., 1997). Threatened fall chinook populations would be supplemented and increased by the Nez Perce tribal hatchery. This hatchery program would benefit the tribes and may have positive effects on wildlife and recreation and tourism resources.



5.17 Relationship Between Short-Term Uses and Long-Term Productivity

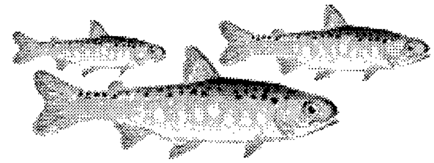
Throughout the Section 5 resource analyses, the resource effects are analyzed with respect to short-term and long-term effects. The long-term effects analyses include consideration of the short-term effect analyses. The following paragraph highlights some of the broader relationships and is not intended to repeat analyses already provided. This discussion presents some of the tradeoffs considering the relationship between short-term uses of humankind's environment and the maintenance and enhancement of long-term productivity.

The choices between Alternative 1—Existing Conditions through Alternative 3—Major System Improvements and Alternative 4—Dam Breaching represent stark tradeoffs between developmental and nondevelopmental values. Alternative 4—Dam Breaching would eliminate electrical energy generation and navigation in the short term and long term. Breaching the dams would also cause short-term impacts including soil erosion, dust generation, degradation of water quality, loss of existing riparian or wetland vegetation, disruption of fish and wildlife habitat, disruption of recreation use, degradation of visual quality, and damage to cultural resources. If operational measures lead to increases in salmon populations in the long term, the productivity of salmon resources would increase and possibly contribute to the long-term recovery of species listed under the Endangered Species Act (ESA). Under Alternative 4—Dam Breaching, however, the long-term use of the river for navigation and power generation would be reduced and eliminated for most related uses. Loss of pumping abilities for irrigators could lead to long-term losses in agricultural productivity. On the positive side, there would be increased recreation opportunities for those activities that require or benefit from free-flowing river conditions. The restoration of a riverine riparian zone and active flood plain may also provide long-term benefits to aquatic and terrestrial communities.



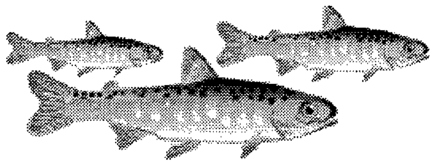
Chapter 6

Plan Selection



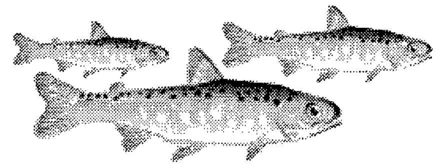
6. Plan Selection

This section will be provided when a preferred alternative is selected.



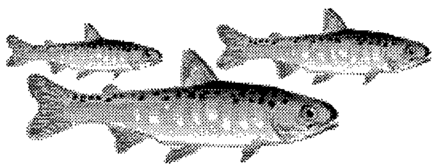
Chapter 7

Plan Implementation



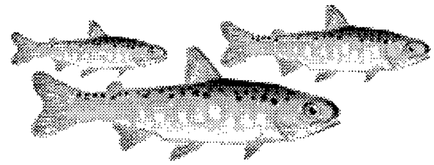
7. Plan Implementation

This section will be provided when a preferred alternative is completed.



Chapter 8

Regional Coordination and Public Outreach



8. Regional Coordination and Public Outreach

Throughout the Lower Snake River Juvenile Salmon Migration Feasibility Study (Feasibility Study), the Corps has been diligent about facilitating two-way communication, input, and participation from involved Federal and state agencies, Native American representatives, elected officials, organizations, and the general public. This input is essential if the Corps is to present an action alternative at the end of the process that reflects consideration of the wide range of resources and people in the region that would be affected by changes to the operation of the Lower Snake River Project and by changes in salmon and steelhead populations. This

section describes activities the Corps has undertaken to involve other agencies and interested parties as they gather information, evaluate options, and develop a plan of action. It specifically addresses regional coordination efforts, the scoping process, the public outreach program, and the Draft FR/EIS public process. A more comprehensive discussion of the public outreach effort associated with the Feasibility Study can be found in Technical Appendix O, Public Outreach Program.

8.1 Regional Coordination

The effects of this study's outcome are expected to be far reaching and involve a variety of entities in the region who are concerned about salmon recovery and effects on other resource areas. Because of this, the Corps has committed to working cooperatively with a variety of groups through a variety of mediums to exchange input and foster understanding. This section describes the Corps' role in those efforts.

8.1.1 Lead and Cooperating Agencies

Because the Corps operates the Lower Snake River Project, they are the lead agency conducting the Feasibility Study and producing the FR/EIS under the National Environmental Policy Act (NEPA) in compliance with the 1995 Biological Opinion issued by the National Marine Fisheries Service (NMFS). The U.S. Environmental Protection Agency (EPA), the U.S. Bureau of Reclamation (BOR), and the Bonneville Power Administration (BPA) are cooperating agencies of this study. Each of the cooperating agencies has special expertise regarding some aspect of the study. Representatives of the cooperating agencies worked with the study team and contributed their expertise to the various work groups conducting technical analyses.

8.1.2 Regional Roundtable Workshops

The Corps held a series of seven roundtable workshops around the region to encourage active participation and involvement in the study by those who wished to follow the study's progress, investigate its technical aspects, discuss the featured topics with the study team, and offer input on specific elements of the study. These meetings were attended by the study team and Federal and state agency representatives, and were open to public citizens, interested organizations, and communities. Table 8-1 lists the locations, dates, and number of participants for each regional roundtable workshop.

Table 8-1. Regional Roundtable Workshops

Town	Date	Meeting Participants
Portland, OR	4/14/97	17
Portland, OR	6/11/97	40
Portland, OR	9/10/97	45
Clarkston, WA	11/12/97	37
Portland, OR	1/21/98	61
Richland, WA	3/18/98	85
Boise, ID	7/15/99	60
Total		345

8.1.3 Work Groups

Many of the analyses conducted for the Feasibility Study were produced through technical work groups. Some work groups studied the impacts of the potential alternatives on certain resource areas, like the Drawdown Regional Economic Workgroup (DREW), which focused on economic issues. The Plan for Analyzing and Testing Hypotheses (PATH) was another resource work group of regional fisheries biologists measuring projected salmon and steelhead survival and recovery rates. There were also work groups of engineers and fisheries biologists designing and testing specific structural changes that could help more salmon and steelhead pass safely through the dams. These work groups are crucial to the Feasibility Study and the Corps' regional coordination effort. Representatives from the Corps; the cooperating agencies; NMFS; USFWS; the Northwest Power Planning Council (NPPC); Native American tribes; state agencies in Washington, Oregon, Idaho, and Montana; academia; and interested organizations contributed their expertise and perspectives to the work groups. Some work group proceedings were open to the public, and the Corps provided some work group products to the public via their website.

8.1.4 Coordination with Other Regional Salmon Recovery Efforts

Throughout the Feasibility Study, the Corps has been working with others in the region to develop and analyze alternative management plans for fish and wildlife resources of the Columbia-Snake River Basin. In terms of an overall improvement in species survival throughout the basin, the Lower Snake River Juvenile Salmon Migration Feasibility Study is only part of the picture. The Corps has been and will continue to coordinate with other entities by sharing valuable technical information and insights as everyone moves closer towards a common vision on salmon recovery in the region. Some of the entities involved in related actions on the Columbia-Snake River System include the Federal Caucus, the Columbia River Basin Forum, and the Multi-Species Framework.

8.2 Scoping Process

As part of the NEPA process, the Corps conducted a series of public scoping meetings in the region for the Feasibility Study and its associated FR/EIS in the summer of 1995. The purpose of the scoping period was to invite comments from interested and potentially affected parties regarding potential study content, direction, and process. Comments received from speakers, letters, and comment cards during the scoping process were reviewed throughout the Feasibility Study and helped to shape the study and the FR/EIS. The comments were classified into 10 general categories as follows:

- Consider the range of alternatives
- Evaluate the juvenile fish transport program
- Incorporate related studies
- Consider the loss of river services during drawdown
- Determine what other factors could be affecting salmon runs
- Evaluate the cost-benefit of drawdown

- Consider the need for a drawdown test
- Coordinate with other agencies
- Consider people's preference for alternative(s)
- Offer analysis based on sound science.

8.3 Public Outreach Program

The Corps has carried out an aggressive outreach effort in the region throughout the Lower Snake River Juvenile Salmon Migration Feasibility Study, in order to both raise awareness and promote involvement. Public interest in the Feasibility Study has been high, and constant communication has been essential because the impacts of the action alternative could be far reaching. The public outreach program began with scoping meetings in 1995 and intensified in 1997 through 1999 with the implementation of the Public Outreach Plan.

8.3.1 Public Outreach Plan

The program goal identified in the Public Outreach Plan is to inform and involve people in the region in the engineering, science, and planning process that will lead to a recommendation on the future operation for fish passage at the Lower Snake River Hydropower Project. Everyone benefits when the public is informed and involved. Individuals and groups can ensure that their perspective is heard and factored into the decisions made, and the Corps ensures that it has considered all the factors and recommended a plan that has full public involvement. This outreach program supports the Corps, cooperating agencies, and the public in working openly and collaboratively toward a recommendation that can be effectively implemented.

The Public Outreach Plan was developed through a cooperative effort involving study management, technical, and public involvement staff from the Corps; and contractor staff specializing in environmental compliance, communications, social science, and public involvement. The plan is based, in part, on current and recent public outreach efforts conducted for similar types of studies, as well as on the collective knowledge and experience of those responsible for drafting the plan. In addition, the plan reflects insights gained through telephone interviews with individuals from a variety of federal agencies, as well as sources representing state agencies, environmental groups, and river user interests in the Pacific Northwest. Those interviewed were asked what the key issues and concerns for the project are, how people obtain information about salmon and river use matters, who would be interested in the study, and what approaches might work best for communicating with interested parties.

The Public Outreach Plan identified the need for the Feasibility Study to engage the public in two ways. When the outreach has taken the form of information, those involved have been an audience. When the outreach has taken the form of involvement, those involved have been participants. Groups targeted for outreach efforts include:

- General public
- Stakeholders

- Elected officials
- Media
- Academia
- Governments
- Agencies
- Government forums
- Native American Tribes (See Appendix Q, Tribal Consultation/Coordination).

Specific public information and public involvement efforts aimed at these groups are described in the next two subsections.

8.3.2 Public Information Efforts

The Corps has worked to raise awareness through a multi-media, multi-technique information campaign. Public information is one-way information, with little or no opportunity for feedback. The purpose of raising awareness is to minimize or eliminate any surprises for decisionmakers or the public about the decision regarding the future of the lower Snake River. The Corps has used a video, a web site, mailing list, printed materials, travelling display, media coverage, and advertising to raise awareness about the existence, purpose, and process of the Feasibility Study. Public information efforts are a necessary foundation for public involvement efforts.

8.3.2.1 Video

To achieve widespread, consistent information dispersal, the Corps produced a 13½-minute video, *The Path of the Salmon*, in 1998 for the public meetings. The video gives a brief history of the decline in salmon numbers, explains the Corps' complex role, and touches on the options available to the Corps as operators of four hydroelectric dams on the river. The video provided the public, user groups, political staffs, agencies, and the internal Corps audience with a factual representation of the study and explained the complexities involved in the recovery of the salmon runs. It also was intended to create enthusiasm and desire to participate in the public involvement program. More than 500 copies of the video in VHS, BETA CAM, and CD-ROM formats have been distributed to an extensive variety of groups, schools, officials, and media.

8.3.2.2 Web Site Page

A web site page http://www.nww.usace.army.mil was established in 1997 to allow internet users access to detailed information about the Feasibility Study (see Technical Appendix O, Public Outreach Program). The web site has proven to be an effective tool for disseminating information to the scientific and educational communities, as well as to stakeholders.

8.3.2.3 Mailing List

The Corps established a mailing list in 1995 to create a network of individuals interested in the study. All subsequent public outreach activities and informational

tools encouraged the public to add their names to the list. The mailing list has steadily increased throughout the study to more than 2,200. The mailing list consists of elected officials, stakeholders, governmental organizations, special interest groups, and interested individuals. The mailing list database has been used to mail out periodic study newsletters and meeting notification cards, as well as for querying specific organizations and contact personnel. Notification of the Draft FR/EIS release and the public meetings will be carried out using the mailing list.

8.3.2.4 Printed Materials

A series of eight newsletters has been produced and sent to the mailing list of parties interested in the Feasibility Study. The newsletters convey study progress and upcoming events to the stakeholders and various interested publics and focus on the issues surrounding the study. Newsletters have been available at public outreach events and have been sent out in response to information requests. Each issue is posted (in PDF format) on pages available through the internet at the Corps' web site. The newsletter has proven to be a valuable tool to keep interested individuals throughout the region informed regarding the study's progress and has also provided an effective means of notification of public meetings on the Feasibility Study.

In addition to the newsletters, the Corps developed a color brochure that presents a succinct summary of the scope of the Feasibility Study, the Corps' role in salmon recovery, and the alternatives being analyzed. The brochure has accompanied the traveling display and all outreach activities so that interested individuals have written material to take with them. It also has been sent out in information packets, along with the newsletters, *Salmon Passage Notes*, newspaper inserts, fact sheets, and often copies of *Path of the Salmon* video. Requests for information about the Feasibility Study have come from a wide variety of sources including students, media, elected officials, stakeholders, and interested citizens.

8.3.2.5 Traveling Displays

Two identical portable traveling displays were produced to present basic study information including the timeline, the three alternative pathways, and lower Snake River map. This four-panel foldout display creates a mural for a stand-alone exhibit that has been used in a variety of settings: county fairs, outdoor shows, office building foyers, libraries, meetings, and visitor centers. Nearly half a million people have viewed the displays throughout Washington, Idaho, and Oregon (see Annex C in Technical Appendix O, Public Outreach Program).

8.3.2.6 Media Coverage

The Walla Walla District Public Affairs Office has coordinated with local, regional, and national press as well as radio and television broadcasting networks on Corps news releases and requests for information on the Feasibility Study. In addition to developing news releases to keep the public informed and correct misinformation, coordination with other offices of the Corps and the area elected officials has been a formidable task accomplished by staff in the Public Affairs Office. Public Affairs Office staff and study team members have worked closely with radio stations and

television networks to provide personal interviews, talk show guests, and source information on the Feasibility Study.

Through the annual Media Day in the spring of 1998 and 1999, the Public Affairs Office invited the media to meet with Corps technical experts, view Lower Granite Lock and Dam facilities, and pick up informational media packets. These annual events have been beneficial to keep the media informed about the Feasibility Study so they can, in turn, inform the public.

8.3.2.7 Advertising

An 8-page, full-color insert was designed and distributed in October and November 1998 in 150,000 copies of community and tribal newspapers throughout the lower Snake River region (see Technical Appendix O, Public Outreach Program for a list of newspapers). The insert included information about the four lower Snake River dams, the alternative pathways being considered, study milestones, public information meeting schedules, and sources for further information on the study. The inserts produced an immediate reaction in the form of a surge of requests to be added to the mailing list. The study web site page received an increase of several hundred visits after the insert was distributed. Because the newspaper insert proved to be an effective, relatively inexpensive method of reaching a large public audience, another insert is planned for when a preferred alternative is selected. In addition to the newspaper insert, the Corps has placed advertisements in various regional newspapers when appropriate to announce public meetings and other public outreach efforts.

8.3.3 Public Involvement Efforts

The public outreach program involved interested parties in a public dialog at key points in the Feasibility Study. Public involvement consists of two-way communication between the target audience and the Corps. The involvement techniques described below (i.e., public meetings, community assessment forums, briefings and presentations, tours, and personal communications) have allowed interested parties to provide the Corps with feedback on specific study issues and on the Feasibility Study and the alternative pathways in general (see Annex D to Technical Appendix O, Public Outreach Program). Through these public involvement efforts, formal as well as informal input from the public has provided Corps staff with ongoing and cumulative perspectives that have shaped the overall study.

At each public involvement effort, the Corps identified how feedback will be used. The input was formally reviewed and, where appropriate, has been incorporated into the study. The input has provided the public with an opportunity to influence study scopes and has increased the opportunity for study team members to be exposed to, and to consider, a huge range of public perspectives.

8.3.3.1 Public Meetings

In addition to providing an opportunity for public participation in regional roundtable and work group meetings, the Corps conducted a series of two regional public information meetings in September 1997 and November 1998. The locations, dates,

and number of participants from these public information meetings are listed in Table 8-2. The objectives of these meetings were to:

- Inform the public and stakeholders about the Feasibility Study status
- Hear public concerns
- Respond to questions
- Stimulate public involvement.

Table 8-2. Public Information Meetings, September 1997 and November 1998

Town	Date	Meeting Participants
September 1997		
Boise, ID	9/17/97	45
Lewiston, ID	9/18/97	100
Kennewick, WA	9/23/97	185
Portland, OR	9/25/97	54
September 1997 Subtotal		***384***
November 1998		
Lewiston, ID	11/9/98	300
Richland, WA	11/12/98	300
Portland, OR	11/16/98	140
Boise, ID	11/19/98	85
Spokane, WA	11/23/98	220
November 1998 Subtotal		***1,045***
Total		**1,429**

A total of 1,429 people attended the two series of public information meetings. The meetings featured a general overview presentation, topical presentations, and question-and-answer sessions. Although formal recording of public comments and questions was not taken during the public information meetings, some study team members took notes on issues that were discussed. Issues raised from the September 1997 meetings were categorized into four broad categories: fish, economics, regional, and study process. The issues identified from the November 1998 meetings were categorized into six broad categories: fish/biological, economic/social, regional concerns, study process, flood control, and engineering. Analysis of the issue categories and distribution has assisted in providing input to specific study technical evaluations, determining public perceptions, and preparing public outreach efforts.

8.3.3.2 Community Assessment Forums

Almost 1,200 people throughout the lower Snake River Basin were involved in a series of 26 interactive community forums (representing 28 communities) dealing with the Feasibility Study from late January to June 1999 (Table 8-3). The

communities were selected to represent the variety of current conditions and potential social impacts in different sized agricultural, timber, recreational, and manufacturing based cities and towns with diverse geographic locations. These community forums were not structured like typical information meetings or public hearings. Community members worked in groups during 4-hour, structured, interactive workshops aimed at identifying their perceptions of potential social and economic impacts associated with the study alternatives.

Table 8-3. Community Forum Participation

Town	Date	Number of Participants	Number of Public Observers[1/]	Total Attendance
Prescott, WA	1/20/99	51	10	61
Washtucna/Kahlotus, WA	1/26/99	71	124	195
Stanfield, OR	2/8/99	14	9	23
Adams, OR	2/8/99	10	3	13
Umatilla, OR	2/9/99	19	14	33
Burbank, WA	2/11/99	70	22	92
Riggins, ID	2/16/99	26	2	28
Enterprise, OR	2/17/99	23	4	27
Kennewick, WA	2/20/99	19	0	19
Colfax, WA	2/25/99	72	21	93
Pasco, WA	2/27/99	10	13	23
Pomeroy, WA	3/3/99	40	19	59
Weippe, ID	3/4/99	21	5	26
Genesee, ID	3/8/99	37	22	59
Lewiston, ID	3/9/99	33	12	45
Clarkston, WA	3/24/99	36	10	46
Orofino, WA	3/25/99	27	8	35
Salmon, ID	6/14/99	33	0	33
Ashton, ID	6/14/99	13	8	21
Firth, ID	6/15/99	15	21	36
Rupert, ID	6/15/99	21	7	28
Twin Falls, ID	6/16/99	18	18	36
Bliss/Hagerman, ID	6/17/99	21	12	33
Homedale, ID	6/17/99	9	2	11
Boise, ID	6/21/99	49	10	59
Cascade, ID	6/22/99	15	0	15
Total		**773**	**376**	**1,149**

1/ Only members of each specific community were invited to participate in that community's forum; people from other communities were classified as public observers. Public observers were, however, invited to provide written comments.

8.3.3.3 Briefings and Presentations

The Feasibility Study has received considerable attention from elected officials and interested organizations. The study team members have attempted to keep elected

officials from all different levels of government and their staffs informed about the study and some of its more controversial aspects through briefings and other contacts.

Study team members have also offered presentations and discussion sessions about the Feasibility Study to interested organizations such as special interest groups, stakeholders, service organizations, universities, and professional societies (see Technical Appendix O, Public Outreach Program for a list). The outreach goal has been to meet all speaking requests to provide timely, firsthand, and accurate Feasibility Study information.

8.3.3.4 Tours of Facilities

Tours of the Walla Walla District hydropower facilities, especially Lower Granite Dam, have been carried out throughout the life of the Feasibility Study. Stakeholders, elected officials, special interest groups, governmental representatives, and the media have all toured facilities to better understand juvenile salmon passage issues. Tours provide an interactive opportunity to explain and to illustrate project improvements, innovative technology, and problem areas, as well as to discuss the study alternatives and their potential impacts.

8.3.3.5 Personal Communications

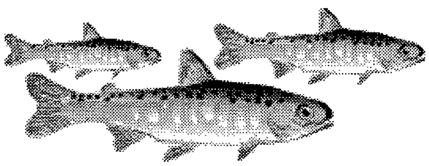
The public involvement coordinator has served as a central point of contact for coordination of public requests. He has been responsible for addressing telephone calls, e-mail messages, comment cards (meetings), letters, and face-to-face comments and questions. Frequent, open communications between the public involvement coordinator and other key members of the study team has facilitated consistent, accurate responses to public requests and comments. Each individual comment, question, and concern has been treated with equal respect and passed along for a response from team members most knowledgeable about the subject of concern. Comments that did not require a response were acknowledged with a post card so concerned parties knew their comment was received and appreciated.

8.4 Draft FR/EIS Public Process

To facilitate agency and public input into the environmental review process, NEPA requires the action agency to provide specific opportunities for public participation in the decision-making process. These opportunities include input to documents during open comment periods and formal testimony through public hearings. The Corps comment period will begin in December, 1999 until March 31, 2000. During this period, all interested parties are invited to submit their comments on the FR/EIS for the formal public record in one of the following ways:

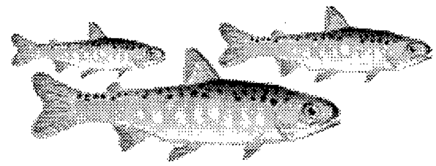
- Mail your comments to: U.S. Army Corps of Engineers, Walla Walla District, Attention, Lower Snake River Study, 201 North Third Avenue, Walla Walla, WA 99362-1876
- Fax your comments to Dave Dankel, Public Involvement Coordinator, at 509-527-7832
- E-mail your comments to salmonstudy@usace.army.mil
- Attend the public meetings and submit written or oral comments.

Public meeting dates and times have not yet been finalized. They will be held February through March throughout the region in up to six locations. Watch your local newspapers, your mailbox (if you are on our mailing list), and/or our website http://www.nww.usace.army.mil for specific information. Written comments will also be accepted at the public meetings. Comments received during the comment period will be considered by the Corps and cooperating agencies as the FR/EIS moves from draft to final stage.



Chapter 9

Compliance with Applicable Federal Environmental Statutes and Regulations



9. Compliance with Applicable Federal Environmental Statutes and Regulations

This section addresses Federal statutes, implementing regulations, and executive orders potentially applicable to the proposed lower Snake River actions. In each case, the text provides a brief summary of the relevant aspects of the law or order. The conclusions on compliance are based on the impact analysis presented in Section 5.0, Environmental Effects of Alternatives and the technical appendices.

9.1 National Environmental Policy Act

This FR/EIS was prepared pursuant to regulations implementing the National Environmental Policy Act (NEPA) (42 USC 4321 et seq). NEPA provides a commitment that Federal agencies will consider the environmental effects of their actions. It also requires that an EIS be included in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The EIS must provide detailed information regarding the proposed action and alternatives, the environmental impacts of the alternatives, potential mitigation measures, and any adverse environmental impacts

that cannot be avoided if the proposal is implemented. Agencies are required to demonstrate that these factors have been considered by decisionmakers prior to undertaking actions.

This FR/EIS was prepared pursuant to NEPA for four alternative actions. The Corps held several series of public meetings and will hold more meetings to gather public opinions and comments on the alternatives and the Draft FR/EIS. Public comments received on the Draft FR/EIS will be addressed in the Final FR/EIS.

9.2 Endangered and Threatened Species and Critical Habitat

The Endangered Species Act (ESA), (16 USC 1531-1544), amended 1988, establishes a national program for the conservation of threatened and endangered species of fish, wildlife, and plants and the habitat upon which they depend. Section 7(a) of the ESA requires Federal agencies to consult with the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS), as appropriate, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their critical habitats.

Section 7(c) of the ESA and the Federal regulations on endangered species coordination (50 CFR § 402.12) require that Federal agencies prepare biological assessments of the potential effects of major actions on listed species and critical habitat. The Corps is consulting with USFWS and NMFS concerning listed species that could be affected by the actions addressed in this FR/EIS. The Final FR/EIS will address the outcome of those consultation processes and the recommendations made by the USFWS and NMFS.

9.3 Fish and Wildlife Conservation

9.3.1 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (FWCA) of 1980 (16 USC 661 et seq.) requires consultation with USFWS when any water body is impounded, diverted, controlled, or modified for any purpose. USFWS and state agencies charged with administering wildlife resources are to conduct surveys and investigations to determine the potential damage to wildlife and the mitigation measures that should be taken. USFWS incorporates the concerns and findings of the state agencies and other Federal agencies, including NMFS, into a report that addresses fish and wildlife factors and provides recommendations for mitigating or enhancing impacts to fish and wildlife affected by a Federal project. The Federal project must include justifiable measures that address USFWS recommendations and concerns. Federal agencies that construct or operate water-control projects are authorized to modify or add to the structures and operation of those projects to accommodate the means and measures for conservation of fish and wildlife.

The Corps has coordinated with USFWS throughout the Feasibility Study process. USFWS staff participated in the analyses conducted by several Corps study groups. USFWS completed the draft Fish and Wildlife Coordination Act Report, which is

appended to the FR/EIS (Technical Appendix M, Fish and Wildlife Coordination Act Report).

9.3.2 Fishery Conservation and Management Act of 1976

The Fishery Conservation and Management Act of 1976 (16 USC 1801-1882; 90 Stat. 331; as amended), also known as Magnuson Fishery Conservation and Management Act, established a 200-mile fishery conservation zone, effective March 1, 1977, and established Regional Fishery Management Councils comprised of Federal and state officials, including the USFWS. The fishery conservation zone was subsequently dropped by amendment and the geographical area of coverage was changed to the Exclusive Economic Zone, with the inner boundary being the seaward boundary of the coastal States. Columbia River salmon and steelhead are found in this zone. Therefore, the potential effects of the alternatives on the fisheries in this zone have been examined in Section 5.0, Environmental Effects of Alternatives.

9.3.3 Migratory Bird Conservation Act

The Migratory Bird Conservation Act (16 USC 715 et seq.,) requires that lands, waters, or interests acquired or reserved for purposes established under the Act be administered under regulations promulgated by the Secretary of the Interior. This act involves conservation and protection of migratory birds in accordance with treaties entered into between the United States and Mexico, Canada, Japan, and the former Union of Soviet Socialist Republics; must protect other wildlife, including threatened or endangered species; and must restore or develop adequate wildlife habitat. The migratory birds protected under this Act are specified in the respective treaties. In regulating these areas, the Secretary of the Interior is authorized to manage timber, range, agricultural crops, and other species of animals, and to enter into agreements with public and private entities.

Section 5.5, Terrestrial Resources, addresses affected avian species as well as other terrestrial species of concern.

9.3.4 Pacific Northwest Electric Power Planning and Conservation Act

The Northwest Power Act was passed by Congress on December 5, 1980 (16 USC 829d-1). This law created the eight-member Northwest Power Planning Council (NPPC), an interstate agency whose members are appointed by the Idaho, Montana, Oregon, and Washington governors. NPPC was entrusted with adopting a Fish and Wildlife Program for the Columbia River Basin by November 1982 and preparing a 20-year Regional Electric Power and Conservation Plan by April 1983. These plans are periodically updated and amended.

NPPC's Fish and Wildlife Program established a number of goals for restoring and protecting fish and wildlife populations in the basin. These goals led to changes in the operation of the Coordinated Columbia River System during the mid-1980s. One of the most notable changes resulted in the Water Budget, which provides for the release of specific amounts of water in the upper Columbia and Snake rivers to help juvenile salmon migrate downstream in the spring. More recently, the NPPC

developed its own proposals to protect threatened and endangered salmon stocks. The NPPC has completed amendments to its Columbia River Basin Fish and Wildlife Program. The amendments adopted to date include mainstem survival, harvest, production, habitat, flow measures that can be used to increase salmon and steelhead runs, and resident fish and wildlife measures. The Corps takes these amendments into consideration when making operating plans.

9.4 Heritage Conservation

A number of Federal laws have been promulgated to protect the nation's historical, cultural, and prehistoric resources.

9.4.1 National Historic Preservation Act

Section 106 of the National Historic Preservation Act (NHPA) (16 USC 470) requires that Federal agencies evaluate the effects of Federal undertakings on historical, archeological, and cultural resources and afford the Advisory Council on Historic Preservation (ACHP) opportunities to comment on the proposed undertaking. The first step in the process is to identify cultural resources included on (or eligible for inclusion on) the National Register of Historic Places that are located in or near the project area. The second step is to identify the possible effects of proposed actions. The lead agency must examine whether feasible alternatives exist that would avoid such effects. If an effect cannot reasonably be avoided, measures must be taken to minimize or mitigate potential adverse effects.

The Corps, in coordination with other Federal agencies, the State Historic Preservation Offices (SHPOs), and Native American tribes, has identified cultural resources and sites in the project area for inclusion on the National Register. In addition, the agencies are evaluating the effects of the proposed alternatives on these sites and measures that might be implemented to mitigate the potential effects. Implementation of any of the alternatives would affect cultural sites to varying degrees. A large area of cultural sites would be exposed with dam breaching. Sites normally inundated might be exposed and subject to impacts from traffic, vandalism, and erosion from wind and waves. Those issues are addressed in Section 5.6, Cultural Resources).

9.4.2 Archeological Resources Protection Act

The Archeological Resources Protection Act (ARPA) (16 USCA 470KK) provides for the protection of archeological sites located on public and Indian lands, establishes permit requirements for the excavation or removal of cultural properties from public or Indian lands, and establishes civil and criminal penalties for the unauthorized appropriation, alteration, exchange, or other handling of cultural properties.

Any of the alternatives could result in continued erosion or exposure of cultural sites and subsequent damage. The drawdown included in Alternative 4—Dam Breaching could result in the new or increased exposure of sites. This in turn could lead to vandalism or an increase in ongoing vandalism at cultural sites. Appropriate monitoring/surveillance methods and awareness programs will need to be developed

to prevent or minimize vandalism as part of overall monitoring and mitigation for cultural resources. The Corps will recommend prosecution of individuals caught vandalizing cultural sites.

9.4.3 Native American Graves Protection and Repatriation Act

The Native American Graves Protection and Repatriation Act (NAGPRA) (25 USCA 3001) addresses the discovery, identification, treatment, and repatriation of Native American and Native Hawaiian human remains and cultural items (associated funerary objects, unassociated funerary objects, sacred objects, and objects of cultural patrimony).

9.4.4 American Indian Religious Freedom Act

The American Indian Religious Freedom Act (AIRFA) of 1978 (42 USCA 1996) established protection and preservation of Native American's rights of freedom of belief, expression, and exercise of traditional religions. Courts have interpreted AIRFA to mean that public officials must consider Native American's interests before undertaking actions that might harm those interests. The Corps will continue to coordinate with affected Native American Tribes on this study and future implementation plans.

9.5 State, Area-Wide, and Local Plan and Program Consistency

The Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 CFR § 1506.2) require agencies to consider the consistency of a proposed action with approved state and local plans and laws. State and local government agencies operate a variety of recreational, infrastructure, and related resources along the river system. Impacts to these resources that could result from the various alternatives are identified in Section 5.0, Environmental Effects of Alternatives.

In accordance with Executive Order 12372, this FR/EIS will be circulated to the appropriate state agencies for review and consultation requirements.

9.6 Coastal Zone Management Consistency

The Coastal Zone Management Act of 1972 (16 USC 1451-1564) requires that Federal actions be consistent, to the maximum extent practicable, with approved state coastal zone management programs. A state coastal zone management program (developed under state law and guided by the Act) sets forth objectives, policies, and standards to guide public and private uses of lands and waters in the coastal zone. The coastal zone as defined in the Act extends inland as far as necessary to account for factors that influence coastal shorelines. Washington and Oregon have approved coastal zone management programs, both of which list seven types of Federal activities directly affecting the coastal zone. The upper boundary of the coastal zone is downstream of Bonneville Dam.

The Feasibility Study alternatives would have little effect on water levels or river uses downstream of Bonneville Dam and therefore all alternatives are in compliance with the Act.

9.7 Environmental Justice

Environmental justice refers to executing a policy of the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws. Increasing concern with environmental equity or justice evolved from a series of studies, conducted in the late 1980s and early 1990s, that suggested that certain types of government and corporate environmental decisions may adversely affect low-income and minority populations to a greater extent than the general population. This finding was particularly the case with locally unpopular land uses, such as landfills and toxic waste sites. Recent guidelines addressing environmental justice include President Clinton's 1994 Executive Order 12898 and accompanying memorandum, the 1996 draft guidelines for addressing environmental justice under NEPA issued by the CEQ, and the 1997 interim guidelines issued by EPA.

EPA's Office of Environmental Justice defines environmental justice as:

> "*The fair and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic group should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies*" (EPA, 1998b).

Potential effects to low income and/or minority populations are discussed in Section 5.13.3.

9.8 Flood Plain Management

If a Federal agency program will affect a flood plain, the agency must consider alternatives to avoid adverse effects in the flood plain or to minimize potential harm. Executive Order 11988 requires Federal agencies to evaluate the potential effects of any actions they might take in a flood plain and to ensure that planning, programs, and budget requests reflect consideration of flood hazards and flood plain management.

The impacts of the alternatives on flood control capability are considered minor or negligible.

9.9 Wetlands Protection

Executive Order 11990 encourages Federal agencies to take actions to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands when undertaking Federal activities and programs. Any agency considering a proposal that might affect wetlands must evaluate factors affecting wetland quality and survival. These factors should include the proposal's effects on the public health, safety, and welfare due to modifications in water supply and water quality; maintenance of natural ecosystems and conservation of flora and fauna; and other recreational, scientific, and cultural uses.

Emergent wetlands communities are prevalent in several areas along the lower Snake River. For wetlands that depend on full pool levels for water supply through subirrigation or shallow inundation, the wetlands might be lost or species composition would be altered with Alternative 4—Dam Breaching.

9.10 Farmland Protection

9.10.1 Farmland Protection Policy Act

The Farmland Protection Policy Act (7 USC 4201 et seq.) requires Federal agencies to identify and take into account the adverse effects of their programs on the preservation of farmlands. Each alternative in this study has been evaluated to determine whether it would cause physical deterioration and/or reduction in productivity of farmlands (see Section 9.10.2).

9.10.2 CEQ Memorandum, August 11, 1990, on Analysis of Impacts on Prime or Unique Agricultural Lands

The CEQ Memorandum establishes criteria to identify and consider the adverse effects of Federal programs on the preservation of prime and unique farmland; to consider alternative actions, as appropriate, that could lessen adverse effects; and to ensure Federal programs are consistent with all state and local programs for protection of farmland. The alternatives in this study were determined not to have a direct impact on prime or unique agricultural lands; direct impacts would be confined to the reservoirs. The Corps actions could, however, diminish the productive capacity of prime or unique agricultural lands that are adversely affected by changes in transportation or irrigation as a result of the project.

9.11 Recreation Resources

9.11.1 Wild and Scenic Rivers Act

The Wild and Scenic Rivers Act (16 USC 1278 et seq.) designates qualifying free-flowing river segments as wild, scenic, or recreational. The Act establishes requirements applicable to water resource projects affecting wild, scenic, or recreational rivers within the National Wild and Scenic Rivers System, as well as rivers designated on the National Rivers Inventory. Under the Act, a Federal agency may not assist the construction of a water resources project that would have a direct and adverse effect on the free-flowing, scenic, and natural values of a Federally designated wild or scenic river. If the project would affect the free-flowing characteristics of a designated river or unreasonably diminish the scenic, recreational, and fish and wildlife values present in the area, such activities should be undertaken in a manner that would minimize adverse impacts and should be developed in consultation with the National Park Service (NPS).

Several reaches of the Snake River have been designated under the Wild and Scenic Rivers System, however, none are within the lower Snake River. The Hells Canyon reach, which is downstream of Brownlee Reservoir, is of primary interest.

The Hanford Reach of the Columbia River was studied by the NPS and an interagency team as a potential Federal Wild and Scenic River. The preferred

alternative in a Final EIS on the Hanford Reach study was distributed in June 1994. It recommended the reach be designated as a combination National Wildlife Refuge and National Wild and Scenic River.

9.11.2 Columbia River Gorge National Scenic Area Act

On November 17, 1986, Congress established the Columbia River Gorge National Scenic Area (Scenic Area) as a Federally recognized and protected area (PL 99-663). The National Scenic Area Act (16 USCA 444 a-p) also created the bi-state Columbia River Gorge Commission and directed the Commission and the USDA Forest Service to jointly develop a management plan for the Scenic Area. The management plan is to reflect legislatively established purposes, which include a mandate to protect and provide for the enhancement of the scenic, cultural, recreational, and natural resources of the Scenic Area.

The Commission adopted a management plan on October 15, 1991. Counties affected by the plan have been encouraged to adopt ordinances consistent with this plan. The plan establishes land use designations for lands within the Scenic Area and specifies broad policies that provide for the protection of resources within the Scenic Area. Feasibility Study alternatives do not include any specific actions at the dams located within the Scenic Area (Bonneville and The Dalles).

9.11.3 Wilderness Act

The Wilderness Act of 1964 (16 USCA 1131 et seq.) established the National Wilderness Preservation System. Areas designated as wilderness under the original act and subsequent wilderness legislation are to be administered for the use and enjoyment of the public in such a manner as to leave them unimpaired as wilderness. Development activities are generally prohibited within wilderness areas, and Federal agencies proposing actions must consider whether the effects of those actions would impair wilderness values. Although there are Wilderness Areas in this basin, none are located on the lower Snake River.

9.11.4 Water Resources Development Act

Congress generally authorizes water resources projects through biennial legislation, such as the Water Resources Development Act (WRDA) of 1990 (33 USC 2201). Section 310(b) of WRDA 1990 requires public participation in changes to reservoir operation criteria. Section 415(b) specifically requires public notification (hearings) of actions associated with drawdown of Dworshak Reservoir. No new drawdowns at Dworshak are contemplated in this FR/EIS. Other requirements of the Act will be met, as applicable under the preferred alternative, when it is designated in the Final FR/EIS.

9.11.5 Federal Water Project Recreation Act

In planning any Federal navigation, flood control, reclamation, or water resource project, the Federal Water Project Recreation Act (16 USCA 4612 et seq.) requires that full consideration be given to the opportunities that the project affords for outdoor recreation and fish and wildlife enhancement. The Act requires planning

with respect to the development of recreation potential. Projects must be constructed, maintained, and operated to provide recreational opportunities, consistent with the purpose of the project.

9.11.6 Land and Water Conservation Fund Act

The Land and Water Conservation Fund Act (LWCFA) (16 USCA 4601-11) assists in preserving, developing, and ensuring accessibility of outdoor recreation resources. The LWCFA establishes specific Federal funding for acquisition, development, and preservation of lands, water, or other interests authorized under the ESA and National Wildlife Refuge Areas Act. Funds appropriated under the Act are allocated to Federal agencies or as grants to states and localities.

9.12 Pollution Control At Federal Facilities

In addition to their responsibilities under NEPA, Federal agencies are required to carry out the provisions of other Federal environmental laws. The alternatives discussed in this FR/EIS do not require any particular response with regard to Federal pollution control laws, which are more concerned with site-specific proposals and alternatives, rather than the broad decisions analyzed in this FR/EIS. They will be addressed as appropriate in any site-specific document tiered to this FR/EIS.

To the extent applicable to an alternative presented in this FR/EIS, compliance with the standards contained in the following legislation will be included in this report:

- Title 42 USC 7401, et seq., The Clean Air Act, as amended (CAA).
- Title 42 USC 300 F, et seq., The Safe Drinking Water Act, as amended.
- Title 42 USC 6901, et seq., The Solid Waste Disposal Act.
- Title 33 USC 2701, et seq., Oil Pollution Act.
- Title 42 USC 9601 [9615] et seq., The Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA).
- Title 7 USC 136, et seq., The Federal Insecticide, Fungicide, and Rodenticide Act, as amended (FIFRA)
- Title 42 USC 6901, et seq., The Resource Conservation and Recovery Act of 1976, as amended (RCRA).
- Title 15 USC, et seq., Toxic Substances Control Act (TSCA), as amended; Title 40 CFR Part 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions."
- Title 42 USC 4901, et seq., The Noise Control Act of 1972, as amended.
- Title 29 USC 651, et seq., Occupational Health and Safety Act.
- Title 33 USC 1251 et. seq., The Federal Water Pollution Control Act (Clean Water Act).

9.13 Relevant Agreements

Implementation of the various proposed alternatives may affect or be affected by other specific relevant agreements. These agreements are not statutes or regulations but are important to consider with Columbia and Snake River actions. This section analyzes and presents the possible implications of implementing the alternatives with respect to the following selected relevant treaties and agreements:

- Canadian Entitlement Allocation Agreement (CEAA)
- Pacific Northwest Coordination Agreement (PNCA)
- Memorandum of Agreement (MOA) on the Bonneville Power Administration's (BPA's) financial commitment for fish and wildlife costs
- MOA on direct funding by BPA of power operation and maintenance costs at Corps projects
- United States Canada Salmon Agreement
- Tribal Treaties
- Specific Water Agreements in Idaho.

These agreements and their relationships to the proposed alternatives are summarized in the following sections.

9.13.1 Canadian Entitlement Allocation Agreement

9.13.1.1 Description

The Columbia River Treaty between the United States and Canada was signed in 1961 and ratified by the Governments in 1964. The Treaty required Canada to construct and operate 15.5 million-acre feet (MAF) of storage on the Columbia River and a tributary in Canada for optimum power generation and flood control downstream in Canada and the United States. Construction of reservoirs in Canada was undertaken at Duncan, Keenleyside (Arrow Lakes), and Mica.

The Treaty established United States and Canadian Entities as the implementing agencies for each Government. The Canadian Government designated British Columbia Hydro and Power Authority as the Canadian Entity. The United States Government designated the Administrator of BPA and the Division Engineer of the Corps, North Pacific Division as the United States Entity. The Entities are charged with carrying out most of the functions agreed to under the Treaty. Either Government has the option to terminate the Treaty (except for certain provisions) after September 2024 with 10 years written notice.

Regulation of streamflows by the three Canadian Treaty reservoirs enables dams downstream in the United States to generate more usable electricity. This increase in usable electricity is referred to as the "downstream power benefits." The Treaty specifies that the downstream power benefits be shared equally between the two countries. Canada's portion of the downstream power benefits is known as the

Canadian Entitlement. The downstream power benefits are derived under a formula prescribed by the Treaty and are determined by computing the difference in the hydroelectric power capable of being produced in the United States base system with and without the use of Canadian storage. The United States base system, defined in Annex B of the Treaty, is essentially the hydroelectric system that existed in the Columbia River Basin in 1961. The Treaty specifies a point on the United States/Canadian border near Oliver, B.C. for the delivery of the Canadian Entitlement power unless a different point of delivery is mutually agreed upon by the United States and Canadian Entities.

The Canadian entitlement has both an energy and capacity component, defined by the Treaty as average annual usable energy and dependable capacity. The energy component may be characterized as the total number of megawatt-hours delivered over a specified time—usually one year. More typically, it is characterized as the average rate of delivery over such a time period, or average megawatts (aMW). The capacity component may be characterized as the maximum rate of delivery allowed in megawatts. Defining a capacity component in excess of the average megawatt energy figure allows the flexibility to shape the returned energy into time periods that more closely reflect the use of the energy, or its marketability.

The Treaty provided that if Canada and the United States agreed, Canada could sell its share of the downstream power benefits in the United States. Canada did not need the additional power at the time the Treaty was signed. Therefore, the Canadian entitlement was initially sold to the Columbia Storage Power Exchange (CSPE), a nonprofit corporation representing a group of 41 Pacific Northwest utilities in the United States, for a period of 30 years from the completion of each dam. These 30-year periods expire in 1998, 1999, and 2003.

9.13.1.2 Discussion of Impacts

The Canadian entitlement is guaranteed by law through at least 2024 and will continue to be provided, regardless of the power system in place. The CEAA is calculated based on theoretical water flows, not by actual water flows. However, there is a clause in the CEAA, which decreases the Canadian entitlement if the region buys more thermal power. As a result, the current level of entitlement will not be impacted by alternatives that leave the dams in place.

Under Alternative 4—Dam Breaching, the Canadian entitlement could decrease at a more rapid rate than under the dam retention alternatives, because the reliance on thermal power resources would occur more rapidly. The rule of thumb for the magnitude of these impacts is a decrease of approximately 3 megawatts (MW) benefit to the Canadians for each additional 100 MW of thermal power.

The expected range of the contribution of Federal and non-Federal sources during the life of the contract is approximately 70 to 75 percent Federal and 25 to 30 percent non-Federal. This range will continue under all alternatives. However, factors that cannot be predicted at this time could cause the percentage allocations to be outside the expected range.

9.13.2 Pacific Northwest Coordination Agreement (PNCA)

9.13.2.1 Description

The PNCA was developed to coordinate Pacific Northwest hydroelectric resources owned or operated by the signatory parties and also allows incidental coordination of other resources (thermal and miscellaneous) at the option of the parties. The parties to the current PNCA are: Montana Power Company, PacifiCorp, Portland General Electric Company, Puget Sound Power and Light Company, Washington Water Power Company, Colockum Transmission Company, Inc., Chelan County Public Utility District (PUD) #1, Cowlitz County PUD #1, Grant County PUD #2, Douglas County PUD #1, Pend Oreille County PUD #1, Snohomish County PUD #1, Seattle City Light, Tacoma City Light, Eugene Water and Electric Board, and the United States through the BOR, Corps, and BPA. The parties annually coordinate planning to estimate the firm load that can reliably be served by the coordinated resources and participate in energy exchanges throughout the contract year to achieve planned firm energy load carrying capacity (FELCC).

The overall purposes of coordination include:

- Optimizing generation through diversities and efficiencies
- Providing certainty in meeting firm load by coordinated resources
- Providing a mechanism to develop benefits from Canadian Storage.

The Columbia River Treaty between the United States and Canada also calls for the two countries to share the power benefits produced downstream in the United States as a result of the development of reservoir storage in Canada. The treaty assumes that the benefits are maximized if this storage is operated as part of a structure coordinated between the major power producers in the Pacific Northwest. In accordance with a set of principles developed by the Secretary of the Interior in 1961, the Pacific Northwest region's non-Federal utilities committed to provide a portion of the share of Treaty benefits the United States was required to deliver to Canada. In return, the U.S. Government agreed to participate in coordinated operation under the same set of principles. The CEAA and PNCA, both signed in 1964, implement those commitments. The CEAA and the PNCA will expire in 2003, but the earliest date possible for expiration of the Treaty is 2024. The parties recently agreed to a new PNCA, that, pending regulatory approval, will likely become effective in the near future.

9.13.2.2 Discussion of Impacts

The PNCA has as its primary goal the coordination of resources to maximize the efficiency and flexibility of operations to meet unusual or severe conditions (such as may occur in severe cold weather conditions). If the power resource remains substantially unchanged, there will typically be little impact on the PNCA. However, flow augmentation occurrences in previous years (e.g., at 427,000 acre feet) have occasionally impacted the PNCA by reducing the flexibility of response. This is the case with Alternatives 1 through 3.

If an alternative under consideration further reduces the flexibility of the resources to meet the unusual or severe conditions, it could negatively impact the PNCA.

Under Alternative 4—Dam Breaching, the hydro-power resource base is reduced and is assumed to be replaced by combined turbine gas generators. The DREW Hydropower Impact Team (DREW HIT), which evaluated the potential impact of the study alternatives on the power system, concluded that 900 MW of production would be the economical level of power replacement. However, in order to develop a system that would meet the demand in severe weather (e.g., meeting the probable load factor required in a 1 in 20 winter), up to 1,550 MW of production would be required. If 1,550 megawatts of power are developed and included in the PNCA, there may be no significant affect on the PNCA. If this level of power is not developed, then the effectiveness of the PNCA could be negatively impacted.

9.13.3 Memorandum of Agreement on the Bonneville Power Administration's (BPA) Financial Commitment for Fish and Wildlife Costs

9.13.3.1 Description

A MOA was entered into by the Department of Energy (on behalf of BPA), the Department of the Army (on behalf of the Corps), the Department of the Interior (on behalf of BOR and the USFWS), and the Department of Commerce (on behalf of the National Oceanic and Atmospheric Administration [NOAA] through the NMFS) to "set forth the expectations of the Parties for the Fiscal Years 1996 through 2001 with regard to the budget commitment of Bonneville's ratepayers for the fish and wildlife costs covered under this Agreement, including a description of the procedures to be used to account for the spending of this budget commitment." The MOA placed a cap on BPA's expenditures for these programs at $252 million per year plus an estimated impact due to operational changes (e.g., lost revenue and/or power purchases).

The BPA fish and wildlife budget commitment and the MOA implementing that commitment are intended to reflect three working principles:

1. Provide greater financial certainty to BPA through a stable, multi-year budget for its fish and wildlife obligations
2. Identify a budget to meet BPA's fish and wildlife funding obligations, barring unforeseen events
3 Ensure that the funds expended for the survival, protection, mitigation, and recovery of dwindling runs of salmon and other fish and wildlife are expended soundly and efficiently."

The MOA recognizes:

1. Decisions on the part of BPA to fund the implementation of the 1995 and 1998 Biological Opinions on the operation of the Federal Columbia River Power System (FCRPS) in the manner and at the funding levels described in this Agreement,

2. Decisions on the part of the Corps and BOR to operate and modify the FCRPS in a manner consistent with the Biological Opinions and reflected in their records of decision on the Biological Opinions
3. The funding commitments in the MOA are adequate to implement the requirements of the Biological Opinions
4. A commitment on the part of BPA to fund the implementation of the Council's Fish and Wildlife Program
5. The Corps and BOR will take the Council's program into account to the fullest extent practicable when deciding on the operations of the FCRPS and other actions that affect fish and wildlife in the Columbia Basin
6. The Parties have also committed to fish and wildlife actions carried out by Columbia River Basin Indian Tribes, the states, and others that are funded by moneys subject to this budget.

The Parties agree that BPA's financial commitment under the MOA for Columbia River Basin fish and wildlife costs for Fiscal Years 1996 through 2001 is as follows:

7. BPA shall absorb the financial consequences of the System operations called for in the 1995 Biological Opinions, supplemented by certain other specific operations
8. With regard to expenditures for fish and wildlife in areas other than system operations, BPA's financial commitment shall average $252 million per year plus interest through these fiscal years for direct program costs (non-capital expenditures for fish and wildlife activities funded directly by BPA), reimbursable expenditures costs (the hydroelectric share of operation and maintenance and other non-capital expenditures for fish and wildlife related activities by the Corps, BOR and USFWS that are funded by Congressional appropriations and then reimbursed to the U.S. Treasury by BPA), and capital investment costs (the projected amortization, depreciation and interest payments for past fish and wildlife-related borrowing by BPA, the portion of past fish and wildlife capital investments by the Corps and BOR for which BPA is already obligated to repay the U.S. Treasury, the hydroelectric share of future fish and wildlife-related capital investments by the Corps and BOR that will be funded by appropriations and then reimbursed to the U.S. Treasury by BPA, based on activities called for in the Biological Opinions, the Council's Fish and Wildlife Program and other authorities, and other capital investments directly funded by BPA borrowing that are based on activities called for in the Biological Opinions and the Council's Fish and Wildlife Program).
9. The Corps, BOR, and USFWS are required to be consistent with regional priorities. The MOA states: "When submitting budget requests for appropriations that will be reimbursed by Bonneville within this category, the regional offices of the Corps of Engineers, Bureau of Reclamation, and USFWS will act in a manner consistent with this Agreement and with the regional priorities and recommendations of the Parties, Tribes, and Council developed under this Agreement pursuant to the procedures described in the Annex. If the President subsequently submits a proposed budget to Congress seeking appropriations for reimbursable expenses that will result in expenditures by Bonneville that differ

from the expected budget allocation (as described in the previous sentence) for this category under this- Agreement, it will be explained to Congress and to the Council and the Tribes the way in which the proposed budget differs from that developed under this Agreement, including an explanation of the reason for this difference and the impact of the difference on the ability to carry out other activities under this Agreement."

9.13.3.2 Discussion of Impacts

This MOA does not limit the fish and wildlife obligations of the various agencies involved under any of the alternatives under consideration. In addition, the MOA only runs through 2001, which is four years before any of the study alternatives are scheduled for implementation.

If the budget for fish and wildlife programs needs to be increased (under any of the alternatives), it could be reflected in a modification of the budget. As a result, the MOA could remain in its present form with a modified budget or be eliminated.

9.13.4 MOA on Direct Funding of Power Operation and Maintenance Costs at Corps Projects

9.13.4.1 Description

The National Energy Policy Act of 1994 (PL 102-486, Section 2406) authorized BPA to direct fund generation additions, improvements, and replacements at Department of Army, North Pacific Region hydropower generation facilities.

A MOA was entered into by BPA and the Department of Army (Corps), subsequent to the Act, on December 4, 1994. This MOA established the framework and administrative details for BPA direct funding of large capital hydropower Operation and Maintenance (O&M) generation additions, improvements, repairs, replacements, or rehabilitations. The Corps headquarters guidance limited the use of this vehicle to non-routine capital items.

Another MOA between BPA and the Department of Army was signed on December 22, 1997. This MOA implements a major policy change by authorizing the funding of hydropower specific baseline and small capital O&M work, and the power portion of joint use costs, from congressional appropriations to direct funding by BPA. The non-power portion of the joint use costs continues to be fully funded by congressional appropriation.

The power share of joint costs account for approximately 90 percent of total costs and non-power share of joint costs account for approximately 10 percent of total costs (based on an average of all four Lower Snake River projects).

The agreement took effect in fiscal year 1999 and will continue in effect until 2008. However, the budget for direct funding has only been estimated through 2003.

9.13.4.2 Discussion of Impacts

The direct funding provisions of the MOA include both O&M and small construction costs. The MOA could continue to operate under any of the alternatives under

consideration. However, if construction costs increase significantly, the budget would need to be modified. This would be the case under both Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 4—Dam Breaching. There could also need to be a modification to the cost allocation process under Alternative 4—Dam Breaching.

9.13.5 Tribal Treaties

9.13.5.1 Description

Two documents prepared for this study shed further light on tribal issues. The Corps prepared Technical Appendix Q, Tribal Consultation/Coordination, which addresses issues related to 14 tribes that are resident in the study area. In addition, the Tribal Circumstances report prepared for this study by Meyer Resources, Inc. in association with the Columbia River Inter Tribal Fisheries Commission (CRITFC) (Meyer Resources, 1999) addresses issues related to the Treaty Tribes. These documents provide additional information on issues related to the tribes and tribal treaties. The tribes included in these reports are (Treaty Tribes are denoted with an asterisk):

- Confederated Tribes of the Warm Springs Reservation of Oregon*
- Burns Paiute Tribe of the Burns Paiute Indian Colony
- Kootenai Tribe of Idaho
- Northwestern Band of Shoshoni Nation
- Shoshone-Paiute Tribes of Duck Valley Reservation, Nevada
- Confederated Tribes of the Colville Reservation
- Nez Perce Tribe of Idaho*
- Coeur d'Alene Tribe of the Coeur d'Alene Reservation
- Confederated Salish and Kootenai Tribes of the Flathead Reservation
- Shoshone-Bannock Tribes of the Fort Hall Reservation*
- Confederated Tribes and Bands of the Yakama Indian Nation of the Yakama Reservation*
- Spokane Tribe of Spokane Reservation
- Confederated Tribes of the Umatilla Reservation*
- Kalispel Indian Community of the Kalispel Reservation.

The Corps has long recognized the sovereign status of Indian tribes. Principles outlined in the Constitution and treaties, as well as those established by federal laws, regulations, and Executive Orders, continue to guide the Corps' national policy towards Indian Nations.

The Corps operates within a government-to-government relationship with Federally recognized Indian tribes. This involves consulting, to the greatest extent practicable and permitted by law, with Indian tribal governments; assessing the impact of agency activities on tribal trust resources and assuring that tribal interests are considered

before the activities are undertaken; and removing procedural impediments to working directly with tribal governments on activities that affect trust property or the governmental rights of the tribes.

The Corps recognizes that tribal governments are sovereign entities, with rights to set their own priorities, develop and manage tribal resources, and be involved in Federal decisions or activities which have the potential to affect these rights. The Corps worked to meet trust obligations, protect trust resources, and to obtain tribal views of trust and treaty responsibilities or actions related to this study, in accordance with provisions of treaties, laws, and Executive Orders as well as principles lodged in the Constitution of the United States. Several tribal chairs/leaders have met with Corps commanders/leaders with regard to the study. The Corps has also reached out, through designated points of contact, to involve tribes in collaborative processes designed to ensure information exchange and consideration of disparate viewpoints.

Technical Appendix Q, Tribal Coordination/Consultation, address the Corps' work toward fulfilling their obligations to preserve and protect trust resources, comply with the Native American Graves Protection and Repatriation Act, and ensure reasonable access to sacred sites in accordance with published and easily accessible guidance.

9.13.5.2 Discussion of Impacts

The tribal impacts of the alternatives under consideration are being evaluated using many resources. These include the Tribal Circumstances and Perspectives report; Cultural Resources; Technical Appendix Q, Tribal Coordination/Consultation; Consultation efforts; and other comments received throughout the study process. The Corps is committed to carrying out their activities in a manner that fulfills their Treaty and Trust obligations. For a more detailed discussion on alternative impacts see Sections 5.6, Cultural Resources and Section 5.7, Native American Indians.

9.13.6 Water Rights Agreements

9.13.6.1 Description

The current flow augmentation program provides approximately 427,000 acre-feet of water. The current program follows the principle of acquiring water only from willing sellers and, after 4 years, there has been permanent acquisition of approximately 78,000 acre-feet of storage space and natural flow rights. Rental pools and other sources provide the remaining volume under current conditions.

The Western States obtained ownership of streams and control of the water within each state upon admission to the United States. Section 8 of the Reclamation Act of 1902 recognizes this principle by requiring that the acquisition and use of water for BOR projects be governed by state law, unless preempted by Federal law. Section 8 (32 Statute 390; 43 U.S.C. □□ 372, 383) states:

> "Nothing in this act shall be construed as affecting or intended to affect or to in any way interfere with the laws of any State or Territory relating to the control, appropriation, use, or distribution of water used in irrigation, or any vested right acquired thereunder, and the Secretary of the Interior, in carrying

> out the provisions of this act, shall proceed in conformity with such laws, and nothing herein shall in any way affect any right of any State or of the Federal government or any landowner, appropriator, or user of water in, to, or from any interstate stream or the waters thereof: Provided, that the right to the use of water acquired under the provisions of this act shall be appurtenant to the land irrigated and beneficial use shall be the basis, the measure, and the limit of the right."

Reclamation storage and release of water for project purposes has complied with state water law. State laws regulate the acquisition and the use of water and limit the use of water to beneficial purposes as determined by the state. Water rights are secured in accordance with state water law, and water rights granted by the state are defined in terms of the type of water use, the period of use, the source of water, the location of the point of diversion and place of use, and the rate and total volume that may be diverted, if applicable (some rights do not involve a diversion). Any changes in water use from those described in the water right definition must generally be authorized by the state through an approval of a transfer of water right. The BOR has secured changes in purpose of use of Oregon natural flow rights and secured interim Idaho legislation approving the use of stored water for flow augmentation.

Watermasters in Idaho and Oregon oversee the local diversion and use of water to assure compliance with water rights of record. These activities tend to be more intense for those stream segments or basins where there is insufficient water to meet all valid water rights. In these cases, the watermasters regulate the diversion of water to assure that the available water supply is distributed to valid rights of record in accord with the prior appropriation doctrine.

9.13.6.2 Discussion of Impacts

Under Alternative 1—Existing Conditions and Alternative 2—Maximum Transport of Juvenile Salmon, there are no major impacts to water rights agreements. Under Alternative 4—Dam Breaching, there would be impacts to irrigators on Ice Harbor Reservoir.

9.13.7 Pacific Salmon Treaty

9.13.7.1 Description

The 1985 Canada-United States Pacific Salmon Treaty was negotiated to ensure conservation and an equitable harvest of salmon stocks. Representatives from the two countries meet annually to review the past year's fishery and to negotiate fishing regimes for future years. The main implementing body for the Treaty is the Pacific Salmon Commission. The Commission is divided into two national sections, with commissioners appointed by each nation. Enabling legislation in the United States prescribes that the U.S. section have one member from Alaska, one from Oregon or Washington, one representing treaty tribes, and one non-voting Federal official. The Canadian section is led by the Federal Department of Fisheries and Oceans and includes representatives from First Nations, recreational and commercial fisheries, as well as the provincial government of British Columbia. The Treaty also established

several scientific and technical committees, which provide the Commission with essential data on the stocks and fisheries.

The two principles on which the Treaty rests are conservation and equity.

- The conservation principle obliges the two parties to prevent overfishing and provide for optimum production.
- The equity principle provides for each country to receive fishery benefits equivalent to the production of salmon from its own rivers.

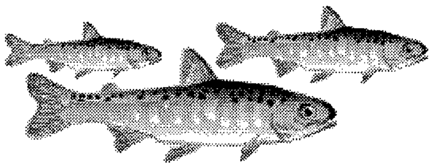
In 1985, when the Treaty was signed, Canada and the United States agreed on fishing arrangements to address chinook conservation problems and limit major interception fisheries in both countries. It was acknowledged, in a Memorandum of Understanding (MOU) attached to the Treaty, that the equity principle was not implemented in 1985. The MOU also provided limited guidance on how the equity principle should be implemented when the necessary data on salmon interceptions were developed.

Although the parties have made substantial improvements in the estimates of stock contributions to intercepting fisheries, agreement on how the equity principle should be implemented has not been reached. The Commission has not been able to agree on key policy issues affecting equity implementation.

9.13.7.2 Discussion of Impacts

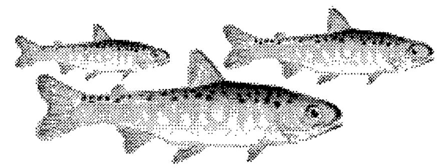
NMFS estimates that "nearly two-thirds of the ocean harvest impacts on Snake River fall chinook occurred in Canadian fisheries during the base period, although this is a very small fraction of the harvest. As a result, substantial ocean impact reductions, which are necessary to protect the listed salmon, can only be achieved with the cooperative involvement of Canada. Canada's cooperation can best be achieved by focusing on the general coast-wide status of wild chinook stocks that have been the concern of the bilateral chinook rebuilding program (and a key element of the Pacific Salmon Treaty) since 1985."

The alternatives under consideration that meet the NMFS jeopardy standards are considered the best options to enhance United States obligations with respect to the Pacific Salmon Treaty.



Chapter 10

Literature Cited



10. Literature Cited

Achord, S., J.R. Harmon, D.M. Marsh, B.P. Sandford, K.W. McIntyre, K.L. Thomas, N.N. Pasch, and G.M. Mathews. 1992. Research Related to Transportation of Juvenile Salmonids on the Columbia and Snake Rivers, 1991. NOAA National Marine Fisheries Service Report to the U.S. Army Corps of Engineers. NMFS. Seattle, Washington.

Ackerman, S.M. 1994. "American White Pelicans Nest Successfully at Crescent Island, Washington." *Washington Birds*. 3:44-49.

Adams, N. S. and D. W. Rondorf. 1998a. Migrational Characteristics of Juvenile Chinook Salmon and Steelhead in the Forebay of Lower Granite Dam Relative to the 1998 Surface Bypass Collector Tests, Preliminary Data Summary Report for Summer 1998 prepared for U.S. Army Corps of Engineers, Walla Walla District. July 1998.

Adams, N. S. and D. W. Rondorf. 1998b. Migrational Characteristics of Juvenile Fall Chinook Salmon in the Forebay of Lower Granite Dam Relative to the 1998 Surface Bypass Collector Tests, Preliminary Data Summary Report for Summer 1998, prepared for U.S. Army Corps of Engineers, Walla Walla District. July 1998.

Adams, N. S. and D. W. Rondorf. 1999. Migrational Characteristics of Juvenile Chinook Salmon and Steelhead in the Forebay of Lower Granite Dam Relative to the 1998 Surface Bypass Collector Tests. Draft Annual Report for 1998. Contract No. E 86930151. Prepared for U.S. Army, Corps of Engineers, Walla Walla, Washington 166p.

Adams, N.S., D. Rondorf, S. Evans, J. Kelly, and R. Perry. 1997. Behavior of Radio-tagged Juvenile Chinook Salmon and Steelhead in the Forebay of Lower Granite Dam as Determined from Fixed-site Receiving Stations. p. 4-1 through 4-66 In: N. Adams, D. Rondorf, E. Kofoot, M. Banach, and M. Tuell. Migrational Characteristics of Juvenile Chinook Salmon and Steelhead in the Forebay of Lower Granite Dam Relative to the 1996 Surface Bypass Collector Tests. Report by U.S. Geological Survey and Nez Perce Tribe of Idaho to the U.S. Army Corps of Engineers, Project No. E-86930151.

AEI (Agricultural Enterprises, Inc.) 1999. Regional Economic Impact Models for the Lower Snake River Juvenile Salmon Migration Feasibility Study. Masonville, Colorado.

Alabaster, J.S. and R. Lloyd. 1982. Finely Divided Soils. In: Water Quality Criteria for Freshwater Fish, 2nd Edition. Food and Agricultural Organization of the United Nations. Butterworth, Boston.

Andelman, S.J. and A. Stock. 1994. Management, Research and Monitoring Priorities for the Conservation of Neotropical Migratory Landbirds that Breed in Washington State. Washington Natural Heritage Program. Washington Department of Natural Resources, Olympia, Washington. 25 pp.

Anderson, J. J. 1998. Decadal Scale Climate Patterns and Salmon Survival Indicators, Interactions, and Implications. NOAA-NMFS-NWFSC TM-29: Estuarine and Ocean Survival of Northeastern Pacific Salmon. School of Fisheries, University of Washington, Seattle, Washington.

Anderson-Perry (Anderson-Perry and Associates). 1991. Investigation of Pumping Facilities-Lower Snake River.

Anthony, R.G., R.L. Knight, G.T. Allen, B.R. McClelland, and J.I. Hodges. 1982. Habitat Use by Nesting and Roosting Bald Eagles in the Pacific Northwest. Trans. N. Am. Wildl. Nat. Res. Conf. 47:332-342.

Arnsberg, B.D. and D.P. Statler. 1996. Assessing Summer and Fall Chinook Salmon Restoration in the Upper Clearwater River and Principal Tributaries. Annual Report by the Nez Perce Tribe, Department of Fisheries Resource Management, Contract DE-BI79-94BL12873, Prepared for the Bonneville Power Administration, Portland, Oregon.

Asherin, D.A. and J. J. Claar. 1976. Volume 3A -- Inventory of Riparian Habitats and Associated Wildlife Along the Columbia and Snake Rivers. Report to ACOE Wildlife Work Group. Idaho Cooperative Wildlife Research Unit, College of Forestry, Wildlife and Range Sciences, University of Idaho. 556 pp.

Backman, T.W.H., A.F. Evans, and M.A. Hawbecker. 1997. Symptoms of Gas Bubble Trauma Induced in Salmon (*Oncorhynchus spp.*) by Total Dissolved Gas Supersaturation of the Snake and Columbia Rivers, USA. Columbia River Inter-Tribal Fish Commission, Portland, Oregon. Report Prepared for Bonneville Power Administration. Project No. 93-008-02, Tasks A.1 and J.1. 50 p.

Baker, V.R., R. Greely, P.D. Komar, D.A. Swanson, and R.B. Waitt, Jr. 1987. Columbia and Snake River Plains. In: W.L. Graf (ed.) Geomorphic Systems of North America. Geological Society of America, Centennial Special, Vol. 2, Boulder, Colorado, pp. 403-468.

Barnes, R.S.K. 1980. The Unity and Diversity of Aquatic Systems. Pages 5-23. In: Barnes, R.S.K. and K.H. Mann (eds). Fundamentals of Aquatic Ecosystems. Blackwell Scientific Publications, Oxford, England, United Kingdom.

Battelle. 1999. Unpublished Geographic Information System Data Provided to Rick Jones, Fisheries Biologist, U.S. Army Corps of Engineers, Walla Walla District.

Beamesderfer, R.C.P., H.A. Schaller, M.P. Zimmerman, C.P. Petrosky, O.P. Langness, and L. LaVoy. 1998. Spawner-recruit data for Spring and Summer Chinook Salmon Populations in Idaho, Oregon, and Washington. Section 2, Chapter 1 In: Marmorek, D.R. and C.N. Peters (eds). 1998. Plan for Analyzing and Testing

Hypotheses (PATH): Retrospective and Prospective Analyses of Spring/Summer Chinook Reviewed in FY 1997. Compiled and Edited by ESSA Technologies Ltd. Vancouver, B.C.

Beamesderfer, R.C., B.E. Rieman, L.J. Bledsoe, and S. Vigg. 1990. "Management Implications of a Model of Predation by a Resident Fish on Juvenile Salmonids Migrating through a Columbia River Reservoir." *North American Journal of Fisheries Management.* 10: 290-304.

Bell, M. 1990. Fisheries Handbook of Engineering Requirements and Biological Criteria. U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon.

Bennett, D.H. and G. Naughton. 1999. Predator Abundance and Salmonid Prey Consumption in Tailrace and Forebay of Lower Granite Dam. Completion Report to U.S. Army Corps of Engineers, Walla Walla District, Project 14-45-0009-1579. 131 p.

Bennett, D.H. and I.C. Shrier. 1986. Effects of Sediment Dredging and In-Water Disposal on Fishes in Lower Granite Reservoir, Idaho-Washington. U.S. Army Corps of Engineers. Walla Walla, Washington.

Bennett, D.H., H.K. Malcolm, and M.A. Madsen. 1997. Thermal and Velocity Characteristics of the Lower Snake River Reservoir, Washington, as a Result of Regulated Upstream Water Releases. Final Completion Report (Project 14-16-009-1579).

Bennett, D.H., J.A. Chandler, and G. Chandler. 1991. Lower Granite Reservoir In-water Disposal Test: Results of the Fishery, Benthic and Habitat Monitoring Program—Year 2 (1989). Completion Report. U.S. Army Corps of Engineers, Walla Walla, Washington.

Bennett, D.H., L.K. Dunsmoor, and J.A. Chandler. 1988. Fish and Benthic Community Abundance at Proposed In-Water Disposal Sites, Lower Granite Reservoir (1987). U.S. Army Corps of Engineers. Walla Walla, Washington.

Bennett, D.H., M.A. Madsen, S.M. Angela, T. Cichosz, T.J. Dresser, M. Davis, and S.R. Chipps. 1997. Draft Fish Interactions in Lower Granite Reservoir: Idaho-Washington. Completion Report Submitted to the Army Corps of Engineers, Walla Walla, Washington.

Bennett, D.H., P.M. Bratovich, W. Knox, D. Palmer, and H. Hansel. 1983. Status of the Warmwater Fishery and the Potential of Improving Warmwater Fish Habitat in the Lower Snake River Reservoirs. Final Report. U.S. Army Corps of Engineers, Walla Walla District. Walla Walla, Washington.

Bennett, D.H., T.J. Dresser, Jr., and M.A. Madsen. 1994. Evaluation of the Effects of the 1992 Test Drawdown on the Fish Communities in Lower Granite and Little Goose Reservoirs, Washington. Appendix P. Prepared for the U.S. Army Corps of Engineers, Walla, Walla District by the University of Idaho, Department of Fish and Wildlife Resources.

Berggren, T.J., and M.J. Filardo. 1993. An Analysis of Variables Influencing the Migration of Juvenile Salmonids in the Columbia River Basin. North American Journal of Fisheries Management 13(1):48-63.

Bjornn, L. Stuehrenberg, R. Ringe, K. Tolotti, P. Keniry, C. Peery, M. Feeley, T. Reischel, and B. Hastings. 1997. Adult Chinook Salmon and Steelhead Migration Studies in the Columbia and Snake Rivers. Abstracts for the 1997 Annual Research Review Anadromous Fish Evaluation Program, October, 1997. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington and Portland District, Portland, Oregon.

Bjornn, T.C. and C.A. Peery. 1992. A Review of Literature Related to Movements of Adults Salmon and Steelhead Past Dams and through Reservoirs in the Lower Snake River, Technical Report 92-1. Prepared by U.S. Fish and Wildlife Service, Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, for U.S. Army Corps of Engineers, Walla Walla District.

Bjornn, T.C., D.R. Craddock, and D.R. Corley. 1968. Migration and Survival of Redfish Lake, Idaho, Sockeye Salmon, *Oncorhynchus nerka*. In: April 5, 1991, 56 FR 14064.

Bjornn, T.C., J.P. Hunt, K.R. Tolotti, P.J. Keniry, and R.R. Ringe. 1994. Migration of Adult Chinook Salmon and Steelhead Past Dams and through Reservoirs in the Lower Snake River and Into Tributaries—1992. Report prepared for U.S. Army Corps of Engineers, Walla Walla District, and U.S. Department of Energy, Bonneville Power Administration, Portland, Oregon. 128 pp.

Bjornn, T.C., J.P. Hunt, K.R. Tolotti, P.J. Keniry, and R.R. Ringe. 1993. Migration of Adult Chinook Salmon and Steelhead Past Dams and through Reservoirs in the Lower Snake River and into Tributaries—1992. Technical Report 93-1 for the U.S. Army Corps of Engineers, Walla Walla District and Bonneville Power Administration by the Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho. Moscow, Idaho.

Bjornn, T.C., K.R. Tolotti, J.P. Hunt, P.J. Keniry, R.R. Ringe, and C.A. Peery. 1998. Passage of Chinook Salmon through the Lower Snake River and Distribution into the Tributaries, 1991-1993. Part I of Final Report for Migration of Adult Chinook Salmon and Steelhead past Dams and through Reservoirs in the Lower Snake River and into Tributaries. Prepared for U.S. Army, Corps of Engineers, Walla Walla, Washington and Bonneville Power Administration, Portland, Oregon. 95 pp.

Bjornn, T.C., R.R. Ringe, K.R. Tolotti, P.J. Keniry, and J.P. Hunt. 1992. Evaluation of Migration Rates and Passage of Adult Chinook Salmon and Steelhead in the Snake River and Tributaries Using Radio Telemetry and Fish Tagging—1991. Technical Report 92-2. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho. Moscow, Idaho.

Blakenship, H.L. and G.W. Mendel (eds.). 1997. Upstream Passage, Spawning, and Stock Identification of Fall Chinook in the Snake River, 1992 and 1993. Final Report. Prepared for U.S. Department of Energy, Bonneville Power Administration, Environment, Fish, and Wildlife. Project No. 92-046, Contract No. DE-BI79-92BP60415. May 1997.

Boe, L. 1988. Canada Goose Production on Lake Wallula and the Lower Snake River, 1974-1987. U.S. Army Corps of Engineers, Walla Walla District. 29 pp.

BOR (U.S. Bureau of Reclamation). 1999. Snake River Flow Augmentation Impact Analysis Appendix. Prepared for the U.S. Army Corps of Engineers Walla Walla District's Lower Snake River Juvenile Salmon Migration Feasibility Study and Environmental Impact Statement.

BOR. 1993. Continued Development of the Columbia Basin Project, Washington – Supplement to the Draft Environmental Impact Statement. Pacific Northwest Region, Boise. Idaho.

BOR. 1989. Draft Environmental Impact Statement, Continued Development of the Columbia Basin Project, Washington. DES89-19. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region. Boise, Idaho.

BPA, Bureau of Indian Affairs, and Nez Perce Tribe. 1997. Nez Perce Tribal Hatchery Program. Final Environmental Impact Statement. DOE/EIS-0213.

BPA, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation. 1995. Final Columbia River System Operation Review Environmental Impact Statement. November 1995.

BPA (Bonneville Power Administration). 1997. 1997 Fast Facts. Accessed at: http://www.bpa.gov.

BPA. 1995. Snake River Sockeye Salmon Sawtooth Valley Project Conservation and Rebuilding Program, Supplemental EIS. Portland, Oregon.

BPA. 1994. Snake River Sockeye Salmon Sawtooth Valley Project Conservation and Rebuilding Program, Final EIS. Portland, Oregon.

BPA. 1993. 1993 Pacific Northwest Loads and Resources Study. U.S. Department of Energy. Bonneville Power Administration. Portland, Oregon.

Brammer, James Allen. 1991. The Effects of Supersaturation of Dissolved Gases on Aquatic Invertebrates of the Bighorn River Downstream of Yellowtail Afterbay Dam, prepared for Montana State University. Bozeman, Montana. March 1991.

Brannon, E.L., R.P. Whitman, and T.P. Quinn. 1981. Report on the Influence of Suspended Volcanic Ash on the Homing Behavior of Adult Chinook Salmon (*Oncorhynchus tshawytscha*). Final Report. Washington Research Center. 30 pp.

Brinson, M.M., B.L. Swift, R.C. Plantico, and J.S. Barclay. 1981. Riparian Ecosystems: Their Ecology and Status. FWS/OBS-81/17. Washington, DC: U.S. Fish and Wildlife Service.

Brown, C.R. 1990. Avian Use of Native and Exotic Riparian Habitats on the Snake River, Idaho. MS Thesis. Colorado State University, Ft. Collins, Colorado. 60 pp.

Buck, D.H. 1956. Effects of Turbidity on Fish and Fishing. Trans. N. Am. Wild. Conf. 21: 249-261.

Busacca, A.J., D.K. McCool, R.I. Papendick, and D.L. Young. 1985. Dynamic Impacts of Erosion Processes on Productivity of Soils in the Palouse In: Proceedings of the National Symposium on Erosion and Soil Productivity, 10-11 December 1984, New Orleans, Louisiana American Society of Civil Engineers, pp. 152-169.

Busby, P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-27. 261 pp.

Buskirk, S.W., L.F. Ruggiero, and C.J. Krebs. 1999. Habitat Fragmentation and Interspecific Competition: Implications for Lynx Conservation. Chapter 4 In: The Scientific Basis for Lynx Conservation (Draft). USDA Forest Service General Technical Report RMRS-GTR-30.

Cachnauer, T.G. 1995. Gas Bubble Trauma Monitoring in the Clearwater River Drainage, Idaho, 1995. Idaho Department of Fish and Game, Lewiston, Idaho.

Cada, Glenn F. Michael D. Deacon, Stephen V. Mitz, and Mark S. Bevelhimer. 1997. Effects of Water Velocity on the Survival of Downstream-Migrating Juvenile Salmon and Steelhead: A Review with Emphasis on the Columbia River Basin *In*: Reviews in Fisheries Science, 5(2): 131-183 (1997).

Carlson, C.D. and G.M. Matthews. 1992. Fish Transportation Studies, Priest Rapids Dam, 1991. Public Utility District No. 2, Grant County, Ephrata, Washington.

Casavant, K.L. and N.S. Lee. 1998. Grain Receipts at Columbia River Grain Terminals: 1980-81 to 1996-97. EWITS Working Paper #9. January 1998.

Cassidy, K.M, C.E. Grue, M.R. Smith, and K.M. Dvornich, eds. 1997. Washington State Gap Analysis—Final Report. Volumes 1-5. Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle, Washington.

Caswell, H. 1989. Matrix Population Models. Sinauer: Sunderlaned, Massachusetts.

CBFWA (Columbia Basin Fish and Wildlife Authority). 1991. Integrated System Plan for Salmon and Steelhead Production in the Columbia River Basin. Portland, Oregon. 527 p.

Ceballos, J.R., S.W. Pettit, and John L. McKern. 1992. NOAA Technical Memorandum NMFS F/NWR-31, Fish Transportation Oversight Team Annual Report—FY 1991. Transport Operations on the Snake and Columbia Rivers. July 1992.

Ceballos, J.R., S.W. Pettit, and J.L. McKern. 1991. Fish Transportation Oversight Team Annual Report—FY 1990. Transport Operations on the Snake and Columbia Rivers. NOAA Technical Memorandum NMFS F/NWR-29. National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Portland, Oregon.

Chandler, J.A. 1993. Consumption Rates of Estimated Total Loss of Juvenile Salmonids by Northern Squawfish in Lower Granite Reservoir, Washington. M.S. Thesis, University of Idaho, Moscow, Idaho. 88 pp.

Chapman, D., A. Giorgi, M. Hill, A. Maule, S. McCutcheon, D. Park, W. Platts, K. Pratt, J. Seeb, L. Seeb, and F. Utter. 1991. Status of Snake River Chinook Salmon. Technical Report Submitted to Pacific Northwest Utilities Conference Committee. Don Chapman Consultants, Inc. Boise, Idaho.

Chapman, D., C. Carlson, D. Weitkamp, G. Matthews, J. Stevenson, and M. Miller. 1997. "Homing in Sockeye and Chinook Salmon Transported around Part of their Smolt Migration Route in the Columbia River." *North American Journal of Fisheries Management.* 17:101-113.

Chapman, D.W. and K.P. McLeod. 1987. Development of Criteria for Fine Sediment in the Northern Rockies Ecoregion. Final Report for EPA Region 10, Work Assignment 273. Battelle Columbus Laboratories. EPA 910/987162. 279 p.

Chapman, D.W., W.S. Platts, D. Park, and M. Hill. 1990. Status of Snake River Sockeye Salmon. Final Report for Pacific Northwest Utilities Conference Committee. Don Chapman Consultants, Inc. Boise, Idaho. 90 p.

Christensen, G.C. 1970. The Chukar Partridge: Its Introduction, Life History and Management. Nevada Dept. Fish Game Biol. Bull. No. 4. 82 pp.

Christy, R.E., and S.D. West. 1993. Biology of Bats in Douglas-fir Forests. General Technical Report PNW-GTR-308, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 28 pp. In: Huff, M.H., R.M. Holthausen, K.B. Aubry (Technical Coordinators). Biology and Management of Old-Growth Forests.

Close, David A., Martin Fitzpatrick, Hiram Li, Blaine Parker, Douglas Hatch, and Gary James. 1995. Status Report of the Pacific Lamprey (*Lampetra Tridentata*) in the Columbia River Basin, prepared for U.S. Department of Energy. Portland, Oregon. July 1995.

Cohen, Felix S. Handbook of Federal Indian Law. 1982 Edition. Charlottesville, Virginia: The Michie Company.

Collis, K., S. Adamany, D.D. Roby, D.P. Craig, and D.E. Lyons. 1999. Avian Predation on Juvenile Salmonids in the Lower Columbia River 1998 Draft Annual Report. Columbia River Inter-Tribal Fish Commission and Oregon Cooperative Fish and Wildlife Research Unit. Prepared for Bonneville Power Administration and U.S. Army Corps of Engineers. September 1999.

Connor, W., H. Burge, R. Nelle, C. Eaton, and R. Waitt. 1996. Rearing and Emigration of Naturally Produced Snake River Fall Chinook Salmon Juveniles. In: D. Rondorf and K. Tiffan, 1994 Annual Progress Report to BPA. pp 44-63.

Connor, W., H. Burge, R. Waitt, and T. Andersen. 1998. Early Life History and Survival of Snake River Natural Subyearling Fall Chinook Salmon in 1996. In: Fall Chinook Salmon Survival and Supplementation Studies in the Snake river and Lower Snake River Reservoirs, 1996. Eds. J.G. Williams and T.C. Bjornn. Prepared for U.S. Department of Energy and Bonneville Power Administration.

Connor, W., H. Burge, S. Smith, D. Rondorf, and K. Tiffan. 1997. Post-Release Attributes and Survival of Natural and Lyons Ferry Hatchery Subyearling Fall Chinook Salmonid Released in the Snake River. In: J. Williams and T. Bjornn (eds.). Fall Chinook Salmon Survival and Supplementation Studies in the Snake River and Lower Snake River, Annual Report 1995.

Cooper, R. and T. Johnson. 1992. Trends in Steelhead Abundance in Washington and along the Pacific Coast of North America. Washington Department of Wildlife, Fish Management Division, Report 92-20. 90 p.

Coronado-Hernandez, Maria C. 1995. Spatial and Temporal Factors Affecting Survival of Hatchery-reared Chinook, Coho, and Steelhead in the Pacific Northwest. Ph.D. Dissertation, University of Washington. Seattle, Washington. 235 p.

Corps and NMFS (U.S. Army Corps of Engineers and National Marine Fisheries Service). 1994. Lower Snake River Biological Drawdown Test Environmental Impact Statement. April 1994.

Corps et al. (U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and Bonneville Power Administration). 1999. Biological Assessment for Effects of FCRPS Operations on Columbia Basin Bull Trout and Kootenai River White Sturgeon. Federal Columbia River Power System Project Operations. June 1999.

Corps (U.S. Army Corps of Engineers). 1999a. Fish Passage Plan for U.S. Army Corps of Engineers Projects. U.S. Army Corps of Engineers, North Pacific Division. Portland, Oregon. February 1999.

Corps. 1999b. Wildlife Observations Database. Unpublished internal record of all wildlife observations.

Corps. 1999c. Pertinent Data. Walla Walla District Projects. Accessed at http://www.nww.usace.army.mil/html/pub/pertdata/pdata.htm.

Corps. 1999d. Lower Snake River Juvenile Salmon Migration Feasibility Report and Environmental Impact Statement—Transportation Report.

Corps. 1999e. Juvenile Fish Transportation Program—1998 Annual Report. U.S. Army Corps of Engineers, Walla Walla District. June 1999.

Corps. 1998a. Lower Snake River Juvenile Salmon Migration Feasibility Study: Lower Snake River Sedimentation. Draft Executive Summary.

Corps. 1998b. 1997 Annual Fish Passage Report, Columbia River Projects and Snake River Projects, Oregon and Washington.

Corps. 1998c. Lower Snake River Juvenile Salmon Migration Feasibility Study Natural River Drawdown Impacts on Recreation: Lower Snake River Recreation Areas.

Corps. 1998d. Activity Distribution Report. U.S. Army Corps of Engineers, North Pacific Division, Walla Walla District. Accessed at http://www.npw.usace.army.mil/.

Corps. 1998e. Monthly Visitation Report. U.S. Army Corps of Engineers, North Pacific Division, Walla Walla District.

Corps. 1998f. Economic Analysis of Water Supply Impacts. November 30, 1998. Ch. 10.

Corps. 1998g. Survey of Farms Irrigated from Ice Harbor Reservoir (unpublished).

Corps. 1997. 1996 Annual Fish Passage Report, Columbia River Projects and Snake River Projects, Oregon and Washington.

Corps. 1996a. System Configuration Study—Phase II. Lower Snake River Juvenile Salmon Migration Feasibility Study—Interim Status Report. December 1996.

Corps. 1996b. Juvenile Fish Transportation Program—1996 Annual Report. Prepared by U.S. Army Corps of Engineers, Walla Walla District, in cooperation with the Washington Department of Fish and Wildlife and the Oregon Department of Fish and Wildlife.

Corps. 1995a. Columbia River System Operation Review; Final Environmental Impact Statement Main Report. U.S. Army Corps of Engineers, North Pacific Division. DOE/EIS-0170.

Corps. 1995b. Record of Decision, Reservoir Regulation and Project Operation, 1995 and Future Years. U.S. Army Corps of Engineers, Pacific Division. Portland, Oregon. March 1995.

Corps. 1994. Regulatory Program Wetland Assessment. Unpublished Report. U.S. Army Corps of Engineers.

Corps. 1993. Final Supplemental EIS—Interim Columbia and Snake River Flow Improvement Measures for Salmon. March 1993.

Corps. 1992. Columbia River Salmon Flow Measures Options Analysis. January 1992.

Corps. 1990. Mule and White-tailed Deer of the Lower Snake River Canyon in Southeast Washington, 1978-1988. Natural Resource Management Branch, Operations Division, U.S. Army Corps of Engineers, Walla Walla District. 30 pp.

Corps. 1975. Lower Snake River Fish and Wildlife Compensation Plan, Lower Snake River, Washington and Idaho-Special Report. U.S. Army, Corps of Engineers, Walla Walla, Washington. 42 pp.

Coues, E. 1893. Meriwether Lewis and William Clark, the History of the Lewis and Clark Expedition. Volume II. Ed. Elliot Coues. Unabridged reprint of 1893 edition. Dover Publications, Inc., New York City, New York.

Craig, J.A. and R.L. Hacker. 1940. History and Development of Columbia River Fisheries. U.S. Bureau of Fisheries Bulletin 49(30):1-216.

CRFMP TAC (Columbia River Fish Management Plan Technical Advisory Committee). 1997. 1996 All-species Review, Columbia River Fish Management Plan. August 4, 1997. U.S. Fish and Wildlife Service, Vancouver, Washington. Technical Advisory Committee, *U.S. versus Oregon.*

Crouse, D.T., L.B. Crowder, and H. Caswell. 1987. A Stage-based Population Model of Loggerhead Sea Turtles and Implications for Conservation. *Ecology*. 68:1412-1423.

Crowder, L.B., D.T. Crouse, S.S. Heppell, and T.H. Martin. 1994. Predicting the Impact of Turtle Excluder Devices on Loggerhead Sea Turtle Populations. *Ecological Applications*. 4:437-445.

Curet, T. 1993. Habitat Use, Food Habits and the Influence on Predation on Subyearling Chinook Salmon in Lower Granite and Little Goose Reservoirs, Washington. M.S. Thesis, University of Idaho, Moscow, Idaho. 44 pp.

Dauble, D.D. and D.G. Watson. 1990. Spawning and Abundance of Fall Chinook Salmon (*Oncorhynchus tshawytscha*) in the Hanford Reach of the Columbia River, 1948-1988. Battelle Memorial Institute, Pacific Northwest Laboratory. Richland, Washington. Rep. PNL-7289, UC-600.

Dauble, D.D., R.P. Mueller, R.L. Johnson, W.V. Mavros, and C.S. Abernethy. 1999. Surveys of Fall Chinook Salmon Spawning Downstream of Lower Snake River Hydroelectric Projects Summary Report 1993-1998, prepared for U.S. Army Corps of Engineers, Walla Walla District, and Pacific Northwest National Laboratory. January 1999.

Dauble, D.D., T.L. Page, and R. William Hanf, Jr. 1989. Spatial Distribution of Juvenile Salmonids in the Hanford Reach, Columbia River. Fishery Bulletin. U.S. 98:775-790.

Dauble, DD. and R. Mueller. 1993. Operational Measures Affecting the Survival of Upstream Migrant Adult Salmonids in the Columbia River Basin.

Dawley, E.M. 1986. Effect of 1985-86 Levels of Dissolved Gas on Salmonids in the Columbia River. Report to U.S. Army Corps of Engineers, Contract DACW57-85-F-0623. 31 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, Washington 98112).

Dawley, E.M., L.G. Gilbreath, E.P. Nunnallee, and B.P. Sandford. 1998. Relative Survival of Juvenile Salmon Passing through the Spillway of The Dalles Dam, 1997. Report to the U.S. Army Corps of Engineers, Contract E9670020. 26 p. (Available from the Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, Washington 98112-2097).

Dell, M.B., M.W, Erho, and B.D. Leman. 1975. Occurrence of Gas Bubble Disease Symptoms on Fish in Mid-Columbia River Reservoirs. Public Utility Districts of Grant, Douglas, and Chelan Counties, Washington.

DeHart, M. 1991. Fish Passage Center Annual Report, 1990. BPA Project No. 87-127. Fish Passage Center of the Columbia Basin Fish and Wildlife Authority. Portland, Oregon. May 1991.

Dennis, B. P.L. Munholland, and J.M. Scott. 1991. Estimation of Growth and Extinction Parameters for Endangered Species. *Ecological Monographs*. 61:115-143.

Diplas, P. and Parker, G. 1985. Pollution of Gravel Spawning Grounds due to Fine Sediment. Project Report No. 240. St. Anthony Falls Hydraulic Lab., University of Minnesota, 145 pp.

Doak, D., P. Kareiva, and B. Klapetka. 1994. Modeling Population Viability for the Desert Tortoise in the Western Mojave Desert. *Ecological Applications*. 4:446-460.

Donaldson, N.C. 1980. Soil Survey of Whitman County, Washington. USDA Soil Conservation Service.

Downs, J.L., B.L. Tiller, M. Witter, and R. Mazaica. 1996. Monitoring and Mapping Selected Riparian Habitat along the Lower Snake River. Prepared for U.S. Army Corps of Engineers, Walla Walla, Washington by Pacific Northwest National Laboratory, Richland, Washington. 74 pp.

DREW HIT (Drawdown Regional Economic Workshop Hydropower Impact Team). 1999. Lower Snake River Juvenile Mitigation Feasibility Study, Technical Report on Hydropower Costs and Benefits. U.S. Army Corps of Engineers, Northwestern Division, and Bonneville Power Administration, co-chairs. March 1999.

DREW Anadromous Fish Workgroup. 1999. Andromous Fish Economic Analysis. Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement.

DREW Social Analysis Workgroup. 1999. Social Analysis Report. Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement.

DREW Transportation Workgroup. 1999. Transportation System Impacts Analysis Report. Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement.

DREW Water Supply Workgroup. 1999. Economic Analysis of Water Supply Effects. Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement.

Dumas, P.C. 1950. Habitat Distribution of Breeding Birds in Southeastern Washington. Condor 52:232-237.

EA Engineering (EA Engineering Science and Technology). 1992. Holter and Hauser Reservoir Studies, Montana, 1990-1991. Analysis of Shoreline Spawning Surveys of Walleye, Yellow Perch, and Kokanee Salmon. Prepared for the Montana Power Company. Butte, Montana.

Ebbesmeyer, C.C. and R.M. Strickland. 1995. Oyster Condition and Climate: Evidence from Willipa Bay. Washington Sea Grant Program, University of Washington, Seattle, Washington. Publ. WSG-MR 95-02, 11 p.

Ebel, W.J. 1997. Fish Passage Problems and Solutions--Major Passage Problems. In: E. Schweibert (ed.). Columbia River Salmon and Steelhead. American Fisheries Society Special Publication No. 10. Washington, D.C. pp. 33-39.

Ebel, W.J. 1970. Effects of Transportation on Survival and Homing Ability of Salmonids from the Snake River. Bureau of Commercial Fisheries Report to U.S. Army Corps of Engineers. National Marine Fisheries Service. Seattle, Washington.

Ebel, W.J. 1974. Snake River Runs of Salmon and Steelhead Trout: Collection and Transportation Experiments at Little Goose Dam, 1971-1974. National Marine Fisheries Service, Northwest Fisheries Center, Seattle, Washington. 3 pp.

Ebel, W.J. and H. Raymond. 1976. Effects of Atmospheric Gas Saturation on Salmon and Steelhead Trout of the Snake and Columbia Rivers. U.S. National Marine Fisheries Service Review 38(7):1-14.

Ebel, W.J., H. Raymond, G. Monan, W. Farr, and G. Tanonaka. 1975. Effects of Atmospheric Gas Supersaturation Caused by Dams on Salmon and Steelhead Trout of the Snake and Columbia Rivers. National Marine Fisheries Service, Northwest Fisheries Center. Seattle, Washington.

Ebel, W.J., H.L. Raymond, C.W. Long, W.M. Marquette, R. Krcma, and D. Park. 1972. Evaluation of Fish Protective Facilities at Little Goose Dam and Review of Other Studies Relating to Protection of Juvenile Salmonids in Columbia and Snake Rivers, 1972. NOAA, National Marine Fisheries Service Report to U.S. Army Corps of Engineers. Seattle, Washington.

Ebel, W.J., H.L. Raymond, C.W. Long, W.M. Marquette, R. Krcma, and D. Park. 1971. Fish-Protective Facilities at Little Goose Dam and Summaries of Other Studies Relating to the Various Measures Taken by the Corps of Engineers to Reduce Losses of Salmon and Steelhead in the Columbia and Snake Rivers. NOAA, National Marine Fisheries Service Report to U.S. Army Corps of Engineers. National Marine Fisheries Service, Seattle, Washington.

Ebel, W.J., R. Krcma, D. Park, H.L. Raymond, E.L. Slatick, E.M. Dawley, and G.A. Swan. 1974. Progress Report Evaluation of Fish Protective Facilities at Little Goose Dam and Review of Other Studies Relating to Protection of Juvenile Salmonids in Columbia and Snake Rivers, 1974. NOAA, National Marine Fisheries Service Report to U.S. Army Corps of Engineers. National Marine Fisheries Service. Seattle, Washington.

Ebel, W.J., R.W. Krcma, and H.L. Raymond. 1973. Evaluation of Fish Protective Facilities at Little Goose Dam and Review of Other Studies Relating to Protection of Juvenile Salmonids in the Columbia and Snake Rivers. 1973. NOAA, National Marine Fisheries Service Report to U.S. Army Corps of Engineers. National Marine Fisheries Service, Seattle, Washington.

Elliott, D. and R. Pascho. 1994. Juvenile Fish Transportation: Impact of Bacterial Kidney Disease on Survival of Spring/Summer Chinook Salmon Stocks. Annual Report 1992. Northwest Biological Science Center, National Biological Survey. September 1994.

Elston, R. 1996. Investigation of Head Burns IS Adult Salmonids, Phase I: Examination of Fish at Lower Granite Dam, July 2, 1996. Final Report. Aquatechnics Inc., Carlsborg, Washington. Prepared for Bonneville Power

Administration, Environment, Fish and Wildlife. Portland, Oregon. Project No. 96-050-00. August 1996.

EPA and NMFS (Environmental Protection Agency and National Marine Fisheries Service). 1971. Columbia River Thermal Effects Study: Volume 1, Biological Effects Study. U.S. Environmental Protection Agency and National Marine Fisheries Service.

EPA (U.S. Environmental Protection Agency). 1999. Columbia River Temperature Assessment: Simulation Methods (Draft). Region 10.

EPA. 1998a. Aerometric Information Retrieval System (AIRS) Executive for Windows, Version 2.0.1.8, National Air Data Branch, Office of Air Quality Planning and Standards, Technical Support Division. Research Triangle Park, North Carolina.

EPA. 1998b. Reviewing for Environmental Justice. EIS and Permitting Resource Guide. EPA Region 10—Environmental Justice Office. August, 1998.

EPA. 1976. Quality Criteria for Water. U.S. Environmental Protection Agency, Washington D.C. 20460.

Everest, F.H., R.L. Beschta, J.C. Scrivener, K.V. Koski, J.R. Sedell, and C.J. Cederholm. 1987. Fine Sediment and Salmonid Production: A Paradox. Pages 98-142 in E.O. Salo and T.W. Cundy (editors). Streamside Management: Forestry and Fisheries Interaction. Control Number 57, Institute of Forest Resources, University of Washington, Seattle, Washington.

Federal Register. Vol. 59, No. 194. September 23, 1994. p. 48855.

Federal Register. Vol. 60, No. 142. July 25, 1995. p. 21744.

Federal Register. Vol. 62, No. 159. August 18, 1997. p. 43937.

Federal Register. Vol. 63, No. 45. March 9, 1998. p. 11482.

Federal Register. Vol. 63, No. 53. March 19, 1998. p. 13347.

Federal Register. Vol. 64, No. 56. March 24, 1999. p. 14308.

Federal Register. Vol. 64, No. 57. March 25, 1999. p. 14508.

Filder, L.E. and S.B. Miller. 1993. British Columbia Water Quality Guidelines for Dissolved Gas Supersaturation. Report to B.C. Ministry of Environment, Canada Department of Fisheries and Oceans. 94 p. plus Appendix. Available from B.C. Ministry of Environment Environment, Water Quality Branch, Water Management Division, 765 Broughton Street, Victoria, B.C.

Filder, L.E. and S.B. Miller. 1994. Draft British Columbia Water Quality Guidelines for Dissolved Gas Supersaturation. Prepared for B.C. Ministry of Environment, Canada Department of Fisheries and Oceans Environment, Canada. February 1994.

Fitzner, R.E. and W.C. Hanson. 1979. A Congregation of Wintering Bald Eagles. Condor 81: 311-313.

Fleming, T. 1981. A Nesting Raptor Survey of the Lower Snake and Columbia Rivers-Lewiston, Idaho to Umatilla, Oregon. Prepared for U.S. Army Corps of Engineers. Walla Walla, Washington. 69 pp.

Foster Wheeler Environmental (Foster Wheeler Environmental Corporation). 1999a. Technical Memorandum—Water Quality/Sediment Transport Impact Analysis. Bellevue, Washington.

Foster Wheeler Environmental. 1999b. Lower Snake River Juvenile Salmon Migration Feasibility Report and Environmental Impact Statement—Draft Social Analysis Report. Bellevue, Washington.

FPC (Fish Passage Center). 1999. Fish Passage Center 1998 Draft Annual Report.

Franklin, J.F. and C.T. Dyrness. 1973. Natural Vegetation of Oregon and Washington. USDA Forest Service General Technical Report PNW-8. 419 pp.

Frest, T.J. and E.J. Johannes. 1992. Effects of the March, 1992 Drawdown on the Freshwater Molluscs of the Lower Granite Lake Area, Snake River, Southeastern Washington and Western Idaho. Deixis Consultants. Seattle, Washington.

Fryer, J.K. 1998. "Frequency of Pinniped-caused Scars and Wounds on Adult Spring-Summer Chinook and Sockeye Salmon Returning to the Columbia River." *North American Journal of Fisheries Management.* 18:46-51.

Fulton, L.A. 1968. Spawning Areas and Abundance of Chinook Salmon (*Oncorhynchus tshawytscha*) in the Columbia River Basin--Past and Present. U.S. Fish and Wildlife Service Special Scientific Report. Fisheries No. 571. 26 pages.

FWPCA (Federal Water Pollution Control Administration). 1967. Water Temperatures Influences, Effects and Controls. Proceedings of the 12th Pacific Northwest Symposium on Water Pollution Research, November 7, 1963. Corvallis, Oregon.

Galbreath, D.S. and R. Moreland. 1953. The Chukar Partridge in Washington. Washington State Game Dept. Biol. Bull. No. 11. 54 pp.

Garrett, M.G., J.W. Watson, and R.G. Anthony. 1993. "Bald Eagle Home Range and Habitat Use in the Columbia River Estuary." *Journal of Wildlife Management.* 57(1):19-27.

Geupel, G.R., D. Hardesty, and G. Ballard. 1993. Status and Distribution of the Landbird Avifauna along Riparian Corridors of the Sacramento River NWR: Results of the 1993 Field Season. A report of the Point Reyes Bird Observatory.

Gilbreath, L.G., E.M. Dawley, R. Ledgerwood, P. Bentley, and S.J. Grabowski. 1993. Relative Survival of Subyearling Chinook Salmon that Have Passed Bonneville Dam Via the Spillway or Second Powerhouse Turbines or Bypass System: Adult Recoveries through 1991. Report to U.S. Army Corps of Engineers, Contract E96910013. National Marine Fisheries Service, Coastal Zone and Estuarine Studies Division, Seattle, Washington. 25 pp. + Appendices.

Giorgi, A. J.R. Warren, and HDR Engineering. 1997. An Evaluation of the Effectiveness of Flow Augmentation in the Snake River, 1991-1995. Phase I—Final Report. BPA Project No. 95-070-00.

Giorgi, A.E., T. Hillman, J. Stevenson, S. Hayes, and C. Peven. 1997. Factors that Influence the Downstream Migration Rates of Juvenile Salmon and Steelhead through the Hydroelectric System in the mid-Columbia River Basin. *North American Journal of Fisheries Management.* 17:268-282.

Gosselink J.B. and W.J. Mitsch. 1993. Wetlands. Van Nostrand Reinhold. Second Edition.

Gregory, R.S. and C.D. Levings. 1998. Turbidity Reduces Predation on Migrating Juvenile Pacific Salmon. Transactions of the American Fisheries Society. 127:275-285.

Hammond, R.J. 1979. Larval Biology of the Pacific Lamprey, *Entosphenus tridentatus* (Gairdner), of the Potlatch River, Idaho. M.S. Thesis. University of Idaho, Moscow, Idaho. 44 pp.

Hanrahan, T.P., D.A. Neitzel, M.C. Richmor, and K.A. Hoover. 1999. Assessment of Drawdown from a Geomorphic Perspective Using Geographic Information Systems. Draft Report. Batelle Pacific Northwest Laboratory.

Hanrahan, T.P., D.A. Neitzel, M.C. Richmond, and K.A. Hoover. 1998. Assessment of Drawdown From a Geomorphic Perspective Using Geographic Information Systems, Lower Snake River. Prepared for U.S. Army Corps of Engineers, Walla Walla, Washington. Prepared by Pacific Northwest National Laboratory, Richland, Washington. 87 pp.

Hare, S.R., N.J. Mantau, and R.C. Francis. 1999. Inverse Production Regimes: Alaska and West Coast Pacific Salmon. *Fisheries*, January 1999.

Harmon, J.R. and E. Slatick. 1989. Use of a Fish Transportation Barge for Increasing Returns of Steelhead Imprinted for Homing. Final Report to the Bonneville Power Administration by NOAA, National Marine Fisheries Service. Seattle, Washington.

Harmon, J.R., B.P. Sandford, K.L. Thomas, Neil N. Paasch, K.W. McIntyre, and G.M. Matthews. 1990. Research Related to Transportation of Juvenile Salmonids on the Columbia and Snake Rivers, 1992. NOAA, National Marine Fisheries Service Report to the U.S. Army Corps of Engineers. NMFS. Seattle, Washington.

Harmon, J.R., D.J. Kamikawa, B.P. Sandford, K.W. McIntyre, K.L. Thomas, Neil N. Paasch, and G.M. Matthews. 1995. Research Related to Transportation of Juvenile Salmonids on the Columbia and Snake Rivers, 1993. NOAA, National Marine Fisheries Service Report to the U.S. Army Corps of Engineers. NMFS. Seattle, Washington.

Harmon, J.R., G.M. Matthews, D.L. Park, and T.E. Ruehle. 1989. Evaluation of Transportation of Juvenile Salmonids and Related Research on the Columbia and Snake Rivers, 1988. NOAA, National Marine Fisheries Service Report to the U.S. Army Corps of Engineers. NMFS. Seattle, Washington.

Harmon, J.R., Neil N. Paasch, K.W. McIntyre, K.L. Thomas, B.P. Sandford, and G.M. Matthews. 1996. Research Related to Transportation of Juvenile Salmonids on the Columbia and Snake Rivers, 1995. NOAA, National Marine Fisheries Service Report to the U.S. Army Corps of Engineers, NMFS, Seattle, Washington.

Harmon, J.R., N.N. Paasch, K.W. McIntyre, K.L. Thomas, B.P. Sandford, and G.M. Matthews. 1996. Research Related to Transportation of Juvenile Salmonids on the Columbia and Snake Rivers, 1994. NOAA, National Marine Fisheries Service Report to the U.S. Army Corps of Engineers. NMFS. Seattle, Washington.

Harmon, J.R., B.P. Sandford, K.W. McIntyre, K.L. Thomas, N.N. Paasch, and G.M. Matthews. 1993. Research Related to Transportation of Juvenile Salmonids on the Columbia and Snake Rivers, 1992. NOAA, National Marine Fisheries Service Report to the U.S. Army Corps of Engineers. NMFS. Seattle, Washington.

Harmon, J.R., B.P. Sandford, K.L. Thomas, N.N. Paasch, K.W. McIntyre, and G.M. Matthews. 1994. Research Related to Transportation of Juvenile Salmonids on the Columbia and Snake Rivers, 1992. NOAA, National Marine Fisheries Service Report to the U.S. Army Corps of Engineers. NMFS. Seattle, Washington.

Harris, C.C., W. McLaughlin, E. Nielsen, and D. Becker. 1999a. Community-Based Social Impact Assessment for Phase I—Southwestern Washington, Northwestern Oregon, and North Central Idaho. Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement. University of Idaho, Moscow, Idaho.

Harris, C.C., W. McLaughlin, D. Becker, E. Nielsen, K. Steer, and G. Fizzell. 1999b. Community-Based Social Impact Assessment for Phase II—Southern Idaho. Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement. University of Idaho, Moscow, Idaho.

Hatch, D.R. and B.L. Parker. 1998. Abundance Monitoring for Columbia and Snake Rivers. In: Pacific Lamprey Research and Restoration Annual Report, 1996. Prepared for U.S. Department of Energy and Bonneville Power Administration.

Hatch, D.R. and B.L. Parker. 1996. Lamprey Research and Restoration Project 1996 Annual Report Part (B) Abundance Monitoring for Columbia and Snake Rivers. Portland, Oregon.

Hayes, M.P. 1997. Status of the Oregon Spotted Frog (*Rana pretiosa sensu stricto*) in the Deschutes Basin and Selected Other Systems in Oregon and Northeastern California with a Rangewide Synopsis of the Species' Status. Final report prepared for The Nature Conservancy under contract to the U.S. Fish and Wildlife Service. Portland, Oregon. 57 pp. + appendices.

Hayward, B.J., and S.P. Cross. 1979. The Natural History of *Pipistrellus hesperus* (Chiroptera Vespertilionidae). Report No. 3, Published by the Office of Research, Western New Mexico University, Silver City, New Mexico. 36 pp.

HDR (HDR Engineering, Inc.) 1999. Lower Snake River Drawdown Study. Appendix B Technical Memoranda. February, 1999. Bellevue, Washington.

Hilderbrand, G.V., S.D. Farley, C.T. Robbins, T.A. Hanley, K. Titus, and C. Servheen. 1996. Use of Stable Isotopes to Determine Diets of Living and Extinct Bears. *Canadian Journal of Zoology*. 74:2080-2088.

Hjort, R.C., B.C. Mundy, and P.L. Hulett. 1981. Habitat Requirements for Resident Fishes in the Reservoirs of the Lower Columbia River. Final Contract Report to U.S. Army Corps of Engineers, Portland District. Portland, Oregon. 180 p.

Holton, G.D. 1990. A Field Guide to Montana Fishes. Montana Department of Fish, Wildlife and Parks, Helena, Montana. 104 pp.

Hooper, P.R. and Swanson D.A. 1987. Evolution of the Eastern Part of the Columbia Plateau. In Schuster, J.E. (editor), Selected Papers on the Geology of Washington: Washington Division of Geology and Earth Resources Bulletin 77. Olympia, Washington. pp. 197-217.

Howell, P., K. Jones, D. Scarnecchia, L. LaVoy, W. Kendra, and D. Ortmann. 1985. Stock Assessment of Columbia River Anadromous Salmonids, Vol. I: Chinook, Coho, Chum, and Sockeye Summaries. U.S. Department of Energy, Bonneville Power Administration. Portland, Oregon. 558 p.

Hunn, E.S. 1990. Nch'I-Wana, The Big River: Mid-Columbia Indians and Their Land. University of Washington Press. Seattle, Washington.

Hurson and 20 Coauthors. 1999. Juvenile Fish Transportation Program 1998 Annual Report. 112p. plus Appendices. Available from U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Hurson, D. and 16 Co-Authors. 1996. Juvenile Fish Transportation Program, 1994 Annual Report.

Idaho Power. 1999. 1999 State and County Economic Forecast (1998-2020). Summary data provided by the State of Idaho, Department of Commerce.

IEAB (Independent Economic Analysis Board of the Northwest Power Planning Council). 1999. River Economics: Evaluating Trade-offs in Columbia River Basin Fish and Wildlife Programs and Policies. Accessed at: http://www.nwppc.org/

ISAB (Independent Scientific Advisory Board). Review of the U.S. Army Corps of Engineers' Capital Construction Program, Part II. B. Dissolved Gas Abatement Program. ISAB Report 98-8. September 29, 1998.

ISG (Independent Scientific Group). 1996. Return to the River: Restoration of Salmonid Fishes in the Columbia River Ecosystem. Northwest Power Planning Council. Portland, Oregon. Publication 96-6. 584 pp.

Iwamoto, R.N. and J. Williams. 1993. Juvenile Salmonid Passage and Survival through Turbines. Report to U.S. Army Corps of Engineers, project E86920049. National Marine Fisheries Service, Coastal Zone and Estuarine Studies Division. Seattle, Washington. 27 pp.

Iwamoto, R.N., W.D. Muir, B.P. Sandford, K.W. McIntyre, D.A. Frost, J.G. Williams, S.G. Smith, and J.R. Skalski. 1994. Survival Estimates for the Passage of Juvenile Chinook Salmon through Snake River Dams and Reservoirs, 1993. NOAA, National Marine Fisheries Service Report to Bonneville Power Administration. NMFS. Seattle, Washington.

Iwamoto, R.N., W.D. Muir, B.P. Sandford, K.W. McIntyre, D.A. Frost, J.G. Williams, S.G. Smith, and J.R. Skalski, 1993. Survival Estimates for the Passage of Juvenile Chinook Salmon through Snake River Dams and Reservoirs, 1993. Coastal Zone and Estuarine Studies Division, National Marine Fisheries Service and Center for Quantitative Science, University of Washington. Seattle, Washington. December 1993.

Jackson, A.D. and P.D. Kissner. 1998. Historic and Current Pacific Lamprey Abundance and Possible Reasons for Population Decline, Based on Oral Interviews and Review of Records and Literature, in CTUIR Ceded Areas of Northeast Oregon and Southeast Washington Subbasins of the Columbia River. In: Pacific Lamprey Research and Restoration Annual Report, 1996. Prepared for U.S. Department of Energy and Bonneville Power Administration.

Jackson, P.L. and A. Jon Kimerling, Ed. 1993. Atlas of the Pacific Northwest. Eighth edition. Oregon State University Press. Corvallis, Oregon.

Jessup, E.L. and K.L.Casavant. 1998. Impact of Snake River Drawdown on Transportation of Grains in Eastern Washington: Competitive and Rail Car Constraints. Draft Copy. EWITS Research Report. May 1998.

Johnson, G.E., C.M. Sullivan, and M.W. Erho. 1992. Hydroacoustic Studies for Developing a Smolt Bypass System at Wells Dam. Fisheries Research. 14:221-237.

Johnson, R.E. and K.M. Cassidy. 1997. Terrestrial Mammals of Washington State: Location Data and Predicted Distributions. Volume 3 in Washington State Gap Analysis—Final Report (K.M. Cassidy, C.E. Grue, M.R. Smith, and K.M. Dvornich, eds.) Washington Cooperative Fish and Wildlife Research Unit, University of Washington. Seattle, Washington. Volumes 1-5.

Johnson, R.L., S.M. Anglea, S.L. Blanton, M.A. Simmons, R.A. Moursund, G.E. Johnson, E.A. Kudera, J. Thomas, and J.R. Skalski. 1999. Hydroacoustic Evaluation of Fish Passage and Behavior at Lower Granite Dam in Spring 1998, Summary of Final Report. Richland, Washington. February 1999.

Jones, K.B. 1988. Comparison of Herpetofaunas of A Natural and Altered Riparian Ecosystem. Pages 222-227 In: Szaro, R.C., K.E. Severson, and D.R. Patton (Technical Coordinators). Management of Amphibians, Reptiles, and Small Mammals in North America. (Flagstaff, Arizona, July 19-21, 1988). USDA Forest Service General Technical Report RM-166. 458 pp.

Kan, T.T. 1975. Systematics, Variation, Distribution, and Biology of Lampreys of the Genus Lampetra in Oregon. Doctoral Dissertation, Oregon State University. Corvallis, Oregon. 194 p.

Kappler, C.J. (ed). 1972. Indian Treaties: 1778-1883. New York: Interland Publishing.

Kleist, T. 1993. Bull Trout Observation Request of 29 October 1993. Washington Department of Wildlife Memorandum to Eric Anderson. Walla Walla District Adult Fish Passage.

Kline, P.A. and J.A. Lamansky, Jr. 1997. Research and Recovery of Snake River Sockeye Salmon. Annual Report for April 1995—April 1996. Idaho Department of Fish and Game IDFG 97-5, prepared for Bonneville Power Administration. Project No. 91-72.

Koehler, G.M. 1990. "Population and Habitat Characteristics of Lynx and Snowshoe Hares in North Central Washington." *Canadian Journal of Zoology*. 68:845-851.

Koehler, G.M., and K.B. Aubry. 1994. Lynx. Chapter 4 in The Scientific Basis for Conserving Forest Carnivores in the Western United States: American Marten, Fisher, Lynx, and Wolverine (Ruggiero et al. Tech. Editors). USDA Forest Service General Technical Report RM-254.

La Bolle, L.D., Jr. 1984. Importance of the Upper Littoral Zone as Rearing Area for Larval and Juvenile Fishes in a Columbia River Impoundment. Thesis. Oregon State University. Corvallis, Oregon.

Ledgerwood D.L., E.M. Dawley, L.G. Gilbreath, P.J. Bently, B.P. Sandford, and M.H. Schiewe. 1990. Relative Survival of Subyearling Chinook Salmon which have Passed Bonneville Dam Via the Spillway or the Second Powerhouse Turbines or Bypass System in 1989, with Comparisons to 1987 and 1988. Report prepared for U.S. Army Corps of Engineers, Contract E85890097. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 64 pp. + appendices.

Ledgerwood, R.D., B.A. Ryan, E.P. Nunnallee, and J.W. Ferguson. 1999. Estuarine Detection fo PIT-Tagged Juvenile Salmonids from the Lower Granite Dam Transportation and Other Studies in a Pair-Trawl, 1999. National Marine Fisheries Service, Fish Ecology Division.

Lee, N.S. and K.L. Casavant. 1998. Impacts of a Snake River Drawdown on Energy Consumption and Environmental Emissions in Transporting Eastern Washington Wheat and Barley. Eastern Washington Intermodal Transportation Study, Washington State University. EWITS Research Report No. 23. March 1998.

Lee, N.S. and K.L. Casavant. 1996. Waterborne Commerce on the Columbia-Snake System. EWITS Research Report #12. October 1996.

Leonard, P.M. and D.J. Orth. 1988. "Use of Habitat Guilds of Fishes to Determine Instream Flow Requirements." *North American Journal of Fisheries Management*. 8:399-409.

Leonard, W.P., H.A. Brown, L.L.C. Jones, K.R. McAllister, and R.M. Storm. 1993. Amphibians of Washington and Oregon. Seattle Audubon Society, The Trailside Series, Seattle, Washington.

Lewke, R.E. and I.O. Buss. 1977. "Impacts of Impoundment to Vertebrate Animals and their Habitats in the Snake River Canyon, Washington." *Northwest Science.* 51:219-270.

Lind, A.J., H.H. Welse, Jr., and R.A. Wilson. 1996. "The Effects of a Dam on Breeding Habitat and Egg Survival of the Foothill Yellow-Legged Frog (*Rana boylii*) in Northwestern California." *Herpetological Review.* 27(2):62-67.

Lloyd, D.S. 1987. "Turbidity as a Water Quality Standard for Salmonid Habitats in Alaska." *North American Journal of Fisheries Management.* 7:34-45.

Long, C.W. 1968. "Diel Movement and Vertical Distribution of Juvenile Anadromous Fish in Turbine Intakes." *Fishery Bulletin.* 66:599-609.

Long, C.W., R.F. Krcma, and F.P. Ossiander. 1968. Research on Fingerling Mortality in Kaplan Turbines—1968. U.S. Bureau of Commercial Fisheries, Biological Laboratory. Seattle, Washington.

Loper, S. and K. Lohman. 1998. Distribution and Abundance of Amphibians and Reptiles in Riparian and Upland Habitats Along the Lower Snake River. Report prepared for the U.S. Army Corps of Engineers, Walla Walla District. February, 1998. 46 pp.

Lucas, B. and J. Lock. 1991. Wild Steelhead Spawning Escapement Estimates for Southwest Washington Streams: 1988-1990. Report No. 91-12. Washington Department of Wildlife. Olympia, Washington.

Lucas, R. 1985. Recovery of Game Fish Populations Impacted by the May 19, 1980 Eruption of Mount St. Helens, Part I. Recovery of Winter-Run Steelhead in the Toutle River Watershed. Fishery Management Report No. 85-9A. Washington Department of Game. Olympia, Washington.

Ludwig, D. 1999. "Is it Meaningful to Estimate a Probability of Extinction?" *Ecology.* 80:298-310.

MacDonald, L.H., A.H. Smart, and R.C. Wissmar. 1991. Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska. EPA/910/9-91-001. Edward Brothers Press. Ann Arbor, Michigan.

Mack, C., L. Kronemann, and C. Eneas. 1994. Lower Clearwater Aquatic Mammal Survey. Final Report. Prepared for Bonneville Power Administration, Portland, Oregon. Prepared by Nez Perce Tribe, Lapwei, Idaho. 135 pp.

Maiolie, M.A. 1988. Dworshak Dam Impacts Assessment and Fishery Investigation. Annual Report FY 1987. U.S. Department of Energy, Bonneville Power Administration, U.S. Fish and Wildlife Service, Project No. 87-99.

Malanson, G.P. 1993. Riparian Landscapes. Cambridge University Press, Cambridge, Great Britain. 296 pp.

Mantau, N.J., S.R. Hare, Y. Zhang, J.M. Wallace, and R.C. Francis. 1997. A Pacific Interdecadal Climate Oscillation with Impacts on Salmon Production. Bulletin of the American Meteorological Society

Marmorek, D.R. (ed.), J.J. Anderson, L. Basham, D. Bouillon, T. Cooney, R. Deriso, P. Dygert, L. Garrett, A. Giorgi, O.P. Langness, D. Lee, C. McConnaha, I. Parnell, C.M. Paulsen, C. Peters, C.E. Petrosky, C. Pinney, H.A. Schaller, C. Toole, E. Weber, P. Wilson, and R.W. Zabel. 1996. Plan for Analyzing and Testing Hypotheses (PATH): Final Report. Retrospective Analyses for Fiscal Year 1996. Compiled by ESSA Technologies, LTD. Vancouver, B.C.

Marmorek, D.R. and C.N. Peters (eds). 1998a. Plan for Analyzing and Testing Hypotheses (PATH). Preliminary Decision Analysis Report on Snake River Spring/Summer Chinook. Draft report compiled and edited by ESSA Technologies, LTD. Vancouver, B.C.

Marmorek, D.R. and C.N. Peters (eds). 1998b. PATH Weight of Evidence Report. Prepared by ESSA Technologies, LTD. Vancouver, B.C.

Marmorek, D.R., C.N. Peters, and I. Parnell (eds). 1998a. PATH Final Report for Fiscal Year 1998. Prepared by ESSA Technologies, LTD. Vancouver, B.C.

Marmorek, D.R. and C.N. Peters (eds.), J. Anderson, R. Beamesderfer, L. Botsford, J. Collie, B. Dennis, R. Deriso, C. Ebbesmeyer, T. Fisher, R. Hinrichsen, M. Jones, O. Langness, L. LaVoy, G. Matthews, C. Paulsen, C. Petrosky, S. Saila, H. Schaller, C. Toole, C. Walters, E. Weber, P. Wilson, and M.P. Zimmerman. 1998b. Plan for Analyzing and Testing Hypotheses (PATH): Retrospective and Prospective Analyses of Spring/summer Chinook Reviewed in FY 1997. Compiled and edited by ESSA Technologies Ltd. Vancouver, B.C.

Marsh, D.M., J.R. Harmon, K.W. McIntyre, K.L. Thomas, N.N. Paasch, B.P. Sandford, D.J. Kamikawa, and G.M. Matthews. 1996. Research Related to Transportation of Juvenile Salmonids on the Columbia and Snake Rivers, 1995. NOAA, National Marine Fisheries Service Report to the U.S. Army Corps of Engineers. NMFS. Seattle, Washington.

Marsh, D.M., J.R. Harmon, N.N. Paasch, K.L. Thomas, K.W. McIntyre, B.P. Sandford, and G.M. Matthews. 1998. Research Related to Transportation of Juvenile Salmonids on the Columbia and Snake Rivers, 1997. Prepared for Fish Ecology Division, Northwest Fisheries Science Center, National Marine Fisheries Service. Seattle, Washington. September 1998.

Marsh, D.M., J.R. Harmon, N.N. Paasch, K.L. Thomas, K.W. McIntyre, B.P. Sandford, and G.M. Matthews. 1997a. Research Related to Transportation of Juvenile Salmonids on the Columbia and Snake Rivers, 1996. NOAA, National Marine Fisheries Service Report to the U.S. Army Corps of Engineers. National Marine Fisheries Service. Seattle, Washington.

Marsh, D.M., J.R. Harmon, N.N. Paasch, K.L. Thomas, K.W. McIntyre, B.P. Sandford, and G.M. Matthews. 1997b. Research Related to Transportation of Juvenile Salmonids on the Columbia and Snake Rivers, 1997 (draft report). NOAA, National Marine Fisheries Service Report to the U.S. Army Corps of Engineers. National Marine Fisheries Service. Seattle, Washington.

Martin, D.J., L.J. Wasserman, R.P. Jones, and E.O. Salo. 1984. Effects of Mount St. Helens Eruption on Salmon Populations and Habitat in the Toutle River. Technical Completion Report for U.S. Department of the Interior, Washington, D.C. October 1984.

Maser, C. 1998. Mammals of the Pacific Northwest: from the Coast to the High Cascades. Oregon State University Press, Corvallis, Oregon. 406 pp.

Mathur, D., P.G. Heisey, E.T. Euston, J.R. Skalski, and S. Hays. 1996. "Turbine Passage Survival Estimation for Chinook Salmon Smolts (*Oncorhynchus tshawytscha*) at a Large Dam on the Columbia River." *Canadian Journal of Fisheries and Aquatic Science.* 53:542-549.

Matthews, G. 1999. Truck Transportation of Juvenile Salmonids at U.S. Army Corps of Engineers Dams. National Marine Fisheries Service, Northwest Fisheries Science Center, Fish Ecology Division. Seattle, Washington. 29 p.

Matthews, G.M. and R.S. Waples. 1991. Status Review for Snake River Spring and Summer Chinook Salmon. U.S. Dept. for Commer., NOAA Technical Memo. National Marine Fisheries Service F/NWC-200, 75 pp.

Matthews, G.M., D.L. Park, J.R. Harmon, C.S. McCutcheon, and A.J. Novotny. 1987. Evaluation of Transportation of Juvenile Salmonids and Related Research on the Columbia and Snake Rivers, 1986. NOAA, National Marine Fisheries Service Report to U.S. Army Corps of Engineers. NMFS. Seattle, Washington.

Matthews, G.M., D.L. Park, T.E. Ruehle, and J.R. Harmon. 1985. Evaluation of Transportation of Juvenile Salmonids and Related Research on the Columbia and Snake Rivers, 1984. NOAA, National Marine Fisheries Service Report to U.S. Army Corps of Engineers. NMFS. Seattle, Washington.

Matthews, G.M., D.L. Park, T.E. Ruehle, and J.R. Harmon. 1988. Evaluation of Transportation of Juvenile Salmonids and Related Research on the Columbia and Snake Rivers, 1986. NOAA, National Marine Fisheries Service Report to U.S. Army Corps of Engineers. NMFS. Seattle, Washington.

Matthews, G.M., J.R. Harmon, S. Achord, O.W. Johnson, and L.A. Kubin. 1990. Evaluation of Transportation of Juvenile Salmonids and Related Research on the Columbia and Snake Rivers. 1989. NOAA, National Marine Fisheries Service Report to U.S. Army Corps of Engineers. NMFS. Seattle, Washington.

Matthews, G.M., S. Achord, J.R. Harmon, O.W. Johnson, D.M. Marsh, B.P. Sandford, N.N. Paasch, K.W. McIntyre, and K.L. Thomas. 1992. Evaluation of Transportation of Juvenile Salmonids and Related Research on the Columbia and Snake Rivers, 1990. NOAA, National Marine Fisheries Service Report to U.S. Army Corps of Engineers. NMFS. Seattle, Washington.

Matthews, G.M., D.L. Park, T.E. Ruehle, and J.R. Harmon. 1985. Evaluation of Transportation of Juvenile Salmonids and Related Research on the Columbia and Snake Rivers, 1984. NOAA, National Marine Fisheries Service Report to U.S. Army Corps of Engineers. NMFS. Seattle, Washington.

Maule, Alec G., John Beeman, Karen M. Hans, Matthew G. Mesa, Philip Haner, and Joseph J. Warren. 1997. Gas Bubble Disease Monitoring and Research of Juvenile Salmonids prepared for U.S. Department of Energy. Portland, Oregon. October 1997.

McAllister, K.R., and W.P. Leonard. 1997. Washington State Status Report for the Oregon Spotted Frog. Washington Department of Fish and Wildlife, Wildlife Management Program, Olympia, Washington. 38 pp.

McCabe Jr., George T. and Charles A. Tracy. 1994. "Spawning and Early Life History of White Sturgeon, *Acipenser transmontanus*, in the Lower Columbia River." *Fishery Bulletin*. 92:760-772. February 1994.

McConnahan, C. 1990. Memorandum to the Monitoring and Evaluation Work Group. Analytical Methods Work Group: Flow/Survival Relationship. June 11, 1990. Portland, Oregon: Northwest Power Planning Council. 1990.

McGinnis, W.J. and H.H Christensen. 1996. The Interior Columbia River Basin: Patterns of Population, Employment, and Income Change. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, Oregon, General Technical Report PNW-GTR-358. August 1996.

McGinnis, W.J., R.H. Phillips, T.L. Raettig, and K.P. Connaughton. 1997. County Portraits of Washington State. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, Oregon, General Technical Report PNW-GTR-400. April 1997.

McKelvey, K.S., K.B. Aubry, and Y.K. Ortega. 1999a. History and Distribution of Lynx in the Contiguous United States. Chapter 8 In: The Scientific Basis for Lynx Conservation (Draft). USDA Forest Service General Technical Report RMRS-GTR-30.

McKelvey, K.S., Y.K. Ortega, G. Koehler, K. Aubry, and D. Brittell. 1999b. Canada Lynx Habitat and Topographic Use Patterns in North Central Washington: A Reanalysis. Chapter 10 In: The Scientific Basis for Lynx Conservation (Draft). USDA Forest Service General Technical Report RMRS-GTR-30.

McKern, J. 1976. Inventory of Riparian Habitats and Associated Wildlife along the Columbia and Snake Rivers-Volume 1, Summary Report. U.S. Army Corps of Engineers, Walla Walla, Washington. 100 pp.

Meekin, T.K., and B.K. Turner. 1974. Tolerance of Salmonid Eggs, Juveniles and Squawfish to Supersaturated Nitrogen. Washington Department of Fisheries Technical Report. 12:78-126.

Mendel, G. and D. Milks. 1997. Upstream Passage and Spawning of Fall Chinnok Salmon in the Snake River. Washington Department of Fish and Wildlife Hatcheries Program. Olympia, Washington. May 1997.

Mendel, G. D. Milks, M. Clizer, and R. Bugert. 1993. Upstream Passage and Spawning of Fall Chinook Salmon in the Snake River. Washington Department of Fisheries, Salmon Culture Division. In: Upstream Passage, Spawning, and Stock Identification of Fall Chinook Salmon in the Snake River, 1992. Eds. H. L. Blankenship and G. W. Mendel. Prepared for U.S. Department of Energy and Bonneville Power Administration, Division of Fish and Wildlife. Project No. 92-046. December 1993.

Mesa, M.G., L.K. Weiland, and A.G. Maule. 1996. Progression and Severity of Gas Bubble Trauma in Juvenile Salmonids. *Transactions of the American Fisheries Society.*

Meyer Resources. 1999. Tribal Circumstances Analysis Report. Completed in association with the Columbia River Intertribal Fish Commission (CRIFTC).

Miklancic, F.J. 1989. Ice Harbor Dam. In: Engineering Geology in Washington, Vol. I. Washington Division of Geology and Earth Resource Bulletin 78. pp. 453-457.

Mladenoff, D.J., T.A. Sickley, R.G. Haight, and A.P. Wydeven. 1995. "A Regional Landscape Analysis and Prediction of Favorable Gray Wolf Habitat in the Northern Great Lakes Region." *Conservation Biology.* 9:2, 279-294.

Moore, W.R. 1996. The Lochsa Story. Mountain Publishing Company, Missoula, Montana. 461 pp.

Moore, W.R. 1984. "Last of the Bitterroot Grizzly." *Montana Magazine.* November.

Muir, W. and 10 Other Authors. 1996. Survival Estimates for the Passage of Juvenile Salmonids through Snake River Dams and Reservoirs. Annual Report to BPA. Project 93-29. 187 pp.

Muir, W.D., S. Smith, K. McIntyre, and B. Sandford. 1998. Project Survival of Juvenile Salmonids Passing through the Bypass System, Turbines, and Spillways with and without Flow Deflectors at Little Goose Dam, 1997. Report to U.S. Army Corps of Engineers. 47 pp. (Available from Northwest Fisheries Science Center, Fish Ecology Division, 2725 Montlake Blvd. E., Seattle, WA 98112-2013).

Muir, W.D., S.G. Smith, E.E. Hockersmith, and M.B. Eppard. 1988. Passage Survival of Hatchery Subyearling Fall Chinook Salmon to Lower Granite, Little Goose, and Lower Monumental Dams, 1996. In: Fall Chinook Salmon Survival and Supplementation Studies in the Snake River and Lower Snake River Reservoirs, 1996. Eds. J.G. Williams and T.C. Bjornn. Prepared for U.S. Department of Energy and Bonneville Power Administration.

Muir, W.D., S.G. Smith, E.E. Hockersmith, M.B. Eppard, W.P. Connor, and B.D. Arnsberg. 1999. Fall Chinook Salmon Survival and Supplementation Studies in the Snake River and Lower Snake River Reservoirs, 1997. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Salmon and Wildlife. Portland, Oregon. March 1999.

Muir, W.D., S.G. Smith, R.N. Iwamoto, D.J. Kamikawa, K.W. McIntyre, E.E. Hockersmith, B.P. Sandford, P.A. Ocker, T.E. Ruehle, and J.G. Williams. 1995. Survival Estimates for the Passage of Juvenile Salmonids through Snake River Dams and Reservoirs, 1994. Annual Report, DOE/BP-10891-2. Bonneville Power Administration. Portland, Oregon. February 1995.

Mullan, J.W. 1984. Overview of Artificial and Natural Propagation of Coho Salmon (*Oncorhynchus kisutch*) on the Mid-Columbia River. U.S. Fish and Wildlife Service Report No. FRI/FAO-84-4. 37 p.

Mullan, J.W., M.B. Dell, S.G. Hays, and J.A. McGee. 1986. Some Factors Affecting Fish Production in the Mid-Columbia River 1934-1983. Report No. FRI/FAO-86-15. U.S. Fish and Wildlife Service, Fisheries Assistance Office.

Muncy, R.J. 1962. Life History of the Yellow Perch, *Perca flavescens*, in Estuarine Waters of Severn River, a Tributary of Chesapeake Bay. Maryland. *Chesapeake Science* 3:143-159.

Mundy, Phillip R. 1994. Transportation of Juvenile Salmonids from Hydroelectric Projects in the Columbia River Basin. Prepared for U.S. Fish and Wildlife Service, Portland, Oregon. May 1994.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T. Lindeley, and R.S. Waples. 1998. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. National Marine Fisheries Service. February 1998. Technical Memorandum NMFS-NMFS-35.

Naughton, G. 1998. Predator Abundance and Salmonid Prey Consumption in the Tailrace and Forebay of Lower Granite Dam and the Upper Arms of Lower Granite Reservoir. MS Thesis. University of Idaho. Moscow, Idaho.

Nebeker, A.V. and J.R. Brett. 1976. "Effects of Air-Supersaturated Water on Survival of Pacific Salmon and Steelhead Smolts." *Transactions of the American Fisheries Society*. 105:338-342.

Nehlsen, W., J.E. Williams, and J.A. Lichatowich. 1991. "Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington." *Fisheries*. 16(2):4-21.

Nelson, W.R. and C.H. Wallburg. 1977. Population Dynamics of Yellow Perch (*Perca flavescens*), Sauger (*Stizostedion canadense*), and Walleye (*S. vitreum vitreum*) in Four Main Stem Missouri River Reservoirs. J. Fish. Res. Board Can. 34: 1748-1763.

Newcombe, C.P. and D.D. MacDonald. 1991. "Effects of Suspended Sediments on Aquatic Ecosystems." *North American Journal of Fisheries Management.* 11:72-82.

Newcombe, C.P. and J.O.T. Jensen. 1996. Channel Suspended Sediment and fisheries: A Synthesis for Quantitative Assessment of Risk and Impact. *North American Journal of Fisheries Management.* 16: 693-727.

Newkirk, J.R., K.A. Eriksen, and K.L. Casavant. 1995. Transportation Characteristics of Wheat and Barley Shipments on Haul Roads to and from Elevators in Eastern Washington. EWITS Research Report #5. March.

NMFS (National Marine Fisheries Service). 1999a. Salmonid Travel Time and Survival Related to Flow Management in the Columbia River Basin. White Paper. Northwest Fisheries Science Center, National Marine Fisheries Service. September 1999.

NMFS. 1999b. Passage of Juvenile and Adult Salmonids Past Columbia and Snake River Dams. White Paper. Northwest Fisheries Science Center, National Marine Fisheries Service and National Oceanic and Atmospheric Administration. Seattle, Washington. October 1999.

NMFS. 1999c. Summary of Research Related to Transportation of Juvenile Anadromous Salmonids around Snake and Columbia River Dams. White Paper. Northwest Fisheries Science Center, National Marine Fisheries Service. Seattle, Washington.

NMFS. 1999d. Predation on Salmonids Relative to the Federal Columbia River Power System. White Paper. Northwest Fisheries Science Center, National Marine Fisheries Service and National Oceanic and Atmospheric Administration. Seattle, Washington. October 1999.

NMFS. 1998. Supplemental Biological Opinion: Operation of the Federal Columbia Power System, Including the Smolt Monitoring Program and the Juvenile Fish Transport Program: A Supplement to the Biological Opinion Signed on March 2, 1995, For the Same Projects. Endangered Species Act—Section 7 Consultation. NMFS. Portland, Oregon.

NMFS. 1995. Biological Opinion: Reinitiation of Consultation on 1994-1998 Operations of the Columbia River Power System and Juvenile Transportation Program in 1994-1998. Endangered Species Act—Section 7 Consultation. NMFS. Portland, Oregon.

Noggle, C.C. 1978. Behavioral Physiological and Lethal Effects of Suspended Sediment on Juvenile Salmonids. Master's Thesis, University of Washington. Seattle, Washington.

Normandeau Associates, Inc. 1999. Lower Snake River Water Quality and Post-Drawdown Temperature and Biological Productivity Modeling Study, Volumes 1 and 2. R-16031.011. Bedford, New Hampshire. May 1999.

Normandeau Associates, Inc. and D. Bennett. 1999. Draft Resident Fish Appendix, Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement.

Normandeau Associates, Inc. and J. Skalski. 1997. Turbine Passage Survival of Chinook Salmon Smolts at the Rock Island Dam Powerhouse I and II, Columbia River, Washington. Draft Report Prepared by Normandeau Associates for Public Utility District No. 1 of Chelan County, Wenatchee, Washington. 20 pp.

Normandeau Associates, Mid-Columbia Consulting, and J.R. Skalski. 1996. Fish Survival in Passage through the Spillway and Sluiceway at Wanapum Dam on the Columbia River, Washington. Prepared for Grant County Public Utilities District by Normandeau Associates, Drumore, Pennsylvania.

NPPC (Northwest Power Planning Council). 1991. Fish and Wildlife Program Amendments (Phase Two). Portland, Oregon.

NPPC. 1986. Compilation of Information on Salmon and Steelhead Losses in the Columbia River Basin. Portland, Oregon. 252 p.

NPPC. 1982. NPPC Fish and Wildlife Program (Section 300 "Water Budget and Mainstream Flows" and Section 400 "Downstream Passage"). Portland, Oregon.

NRC (National Research Council). 1996. Upstream: Salmon and Society in the Pacific Northwest. National Academy Press, Washington, D.C.

ODFW and WDFW (Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife). 1998. Status Report. Columbia River Fish Runs and Fisheries, 1938-1997. Oregon.

ODFW. 1991. 1991 All Species Review, Columbia River Fish Management Plan. Technical Advisory Committee. Clackamas, Oregon.

Oelklaus, W.F. III. 1976. Chukar Partridge Dispersion along the Middle and Lower Snake and Columbia Rivers. M.S. Thesis. University of Idaho. Moscow, Idaho. 56 pp.

Olney, F.E. and Members of the Ad Hoc Transportation Review Group. 1992. Review of Salmon and Steelhead Transportation Studies in the Columbia and Snake Rivers, 1984-1989. Report Submitted to the Columbia Basin Fish and Wildlife Authority.

Olsen, D. and J. Richards. 1994. Inter-Basin Comparison Study, Columbia River Salmon Production Compared to Other West Coast Production Areas, Phase II Analysis. Study Sponsored by U.S. Army Corps of Engineers.

Parente, W.D. and J.G. Smith. 1981. Columbia River Backwater Study: Phase II. U.S. Fish and Wildlife Service. Vancouver, Washington. 87 pp. plus Appendices.

Park, D.L. 1993. Transportation as a Means of Increasing Juvenile Salmon Survival. Report for S.P. Cramer and Associates. Gresham, Oregon.

Park, D.L. and J.B. Athearn. 1985. Comprehensive Report of Juvenile Salmonid Transportation. Walla Walla District, U.S. Army Corps of Engineers, Walla Walla, Washington.

Park, D.L. and W.J. Ebel. 1975. Snake River Runs of Salmon and Steelhead Trout: Collection and Transportation Experiments at Little Goose Dam, 1971-75. NOAA, National Marine Fisheries Service. Seattle, Washington.

Park, D.L., G.M. Matthews, J.R. Smith, T.E. Ruehle, J.R. Harmon, and S. Achord. 1984. Evaluation of Transportation of Juvenile Salmonids and Related Research on the Columbia and Snake Rivers, 1983. NOAA, National Marine Fisheries Service Report to U.S. Army Corps of Engineers. NMFS, Seattle, Washington.

Park, D.L., G.M. Matthews, T.E. Ruehle, J.R. Harmon, E. Slatick, and F. Ossiander. 1986. Evaluation of Transportation of Juvenile Salmonids and Related Research on the Columbia and Snake Rivers, 1985. NOAA, National Marine Fisheries Service Report to U.S. Army Corps of Engineers. NMFS. Seattle, Washington.

Park, D.L., G.M. Matthews, T.E. Ruehle, J.R. Smith, J.R. Harmon, B.H. Monk, and S. Achord. 1983. Transportation Research on the Columbia and Snake Rivers, 1982. NOAA, National Marine Fisheries Service Report to U.S. Army Corps of Engineers. NMFS. Seattle, Washington.

Park, D.L., J.R. Harmon, B.H. Monk, T.E. Ruehle, T.W. Newcomb, L.R. Basham, and T.A. Flagg. 1981. Transportation Research on the Columbia and Snake Rivers, 1980. NOAA, National Marine Fisheries Service Report to U.S. Army Corps of Engineers. NMFS. Seattle, Washington.

Park, D.L., J.R. Smith, E. Slatick, G.M. Matthews, L.R. Basham, and G.A. Swan. 1978. Evaluation of Fish Protective Facilities at Little Goose and Lower Granite Dams and Review of Mass Transportation Activities, 1977. NOAA, National Marine Fisheries Service Report to U.S. Army Corps of Engineers. National Marine Fisheries Service. Seattle, Washington.

Park, D.L., J.R. Smith, G.M. Matthews, L.R. Basham, G.A. Swan, G.T. McCabe, T.R. Ruehle, J.R. Harmon, and B.H. Monk. 1979. Transportation Activities and Related Research at Lower Granite, Little Goose, and McNary Dams, 1978. NOAA, National Marine Fisheries Service Report to U.S. Army Corps of Engineers. National Marine Fisheries Service. Seattle, Washington.

Park, D.L., T.E. Ruehle, J.R. Harmon, and B.H. Monk. 1980. Transportation Research on the Columbia and Snake Rivers, 1979. NOAA, National Marine Fisheries Service Report to U.S. Army Corps of Engineers. National Marine Fisheries Service. Seattle, Washington.

Parsley, M.J. and L.G. Beckman. 1994. "Sturgeon Spawning and Rearing Habitat in the Lower Columbia River." *North American Journal of Fisheries Management.* 14:812-827.

Parsley, M.J, L.G. Beckman, and G.T. McCabe, Jr. 1993. "Spawning and Rearing Habitat Use by White Sturgeons in the Columbia River Downstream from McNary Dam." *Transactions of the American Fisheries Society.* 122: 217-227.

Peone, T.L., A.T. Scholz, J.R. Griffith, S. Graves, and M.G. Thatcher, Jr. 1990. Lake Roosevelt Fisheries Monitoring Program. Annual Report. Bonneville Power Administration. Portland, Oregon.

Perkins, J.M., and C. Levesque. 1987. Distribution, Status, and Habitat Affinities of Townsend's Big-eared Bat *(Plecotus townsendii)* in Oregon. Oregon Department of Fish and Wildlife, Nongame Wildlife Program, Technical Report #86-5-01. 49 pp.

Perkins, W.A. and M.C. Richmond. 1999. Long-term, One-dimensional Simulation of Lower Snake River Temperatures for Natural River and Current Conditions, Draft Report. Pacific Northwest Laboratory, Richland, Washington.

Perkins, J.M., and T. Schommer. Undated. Survey Protocol and an Interim Species Conservation Strategy for Plecotus Townsendii in the Blue Mountains of Oregon and Washington. Wallowa-Whitman National Forest, Baker City, Oregon.

Peters, C., I. Parnell, D. Marmorek, R. Gregory, and T. Eppel (eds). 1998. Conclusions and Recommendations from the PATH Weight of Evidence Workshop, September 8-10, 1998, ancouver, B.C. Canada. ESSA Technologies Ltd., ValueScope Research, and Decision Insights. October 9, 1998.

Peters, C.N., D.R. Marmorek, and I. Parnell (eds). 1999. PATH Decision Analysis Report for Snake River Fall Chinook. Prepared by ESSA Technologies Ltd. Vancouver, B.C. 317 pp.

Petersen, J. and T.P. Poe. 1998. Predicting and Assessing the Effects of Reservoir Drawdown on Juvenile Salmonids and their Predators. Research proposal. Project Number DDS-W-98-4. U.S. Geologicial Survey, Biological Resources Division, Cook, Washington. 14 pp.

Petersen, J., C. Barfoot, S. Sauter, D. Gadomski, P. Connolly, and T. Poe. 1999. Predicting the Effects of Dam Breaching in the Lower Snake River on Predators of Juvenile Salmon, prepared for U.S. Army Corps of Engineers, Walla Walla District. May 1999.

Petrosky, C.E. 1998a. Smolt-to-Adult Return Rate Estimates of Snake River Aggregate Wild and Hatchery Steelhead. November 30, 1998. Idaho Department of Fish and Game. Boise, Idaho. 8 pages plus attachments.

Petrosky, C.E. 1998b. Snake River SAR--FGE Sensitivity. Memorandum to C. Toole (NMFS) and Others, Including Attached Spreadsheets STFGESEN.XLS from Idaho Department of Fish and Game. Boise, Idaho. April 3, 1998.

Petrosky, C.E., and H. Schaller. 1998. Smolt-to-Adult Return Rate Estimates of Snake River Aggregate Wild Spring and Summer Chinook. Submission 10 In: D. Marmorek and C. Peters (eds.). PATH Weight of Evidence Report.

Petrosky, C.E. 1991. Influence of Smolt Migration Flows on Recruitment and Return Rates of Idaho Spring Chinook. Idaho Department of Fish and Game, Boise, Idaho. 23 pp.

Petrosky, C.E. Unpublished Manuscript. Analysis and Implications of Alternative Flow-Smolt Survival Models to Snake River Spring/Summer Chinook Recovery through Mainstem Velocity Improvements. Idaho Department of Fish and Game. Boise, Idaho. 7 p.

Pevar, S.L. 1992. The Rights of Indians and Tribes: The Basic ACLU Guide to Indian and Tribal Rights. Second Edition. An American Civil Liberties Union Handbook. Southern Illinois University Press. Carbondale, Illinois.

Philpott, W. 1997. Summaries of the Life History of California Bat Species. Sierra National Forest, Pineridge Ranger District.

Poe, T.P. and B.E. Rieman. 1988. Predation by Resident Fish on Juvenile Salmonids in John Day Reservoir, 1983-1986. Vol. 1. Final Report of Research. Bonneville Power Administration. Portland, Oregon.

Poe, T.P., H.C. Hansel, S.Vigg, D.E. Palmer, and L.A. Prendergast. 1991. "Feeding of Predaceaous Fishes on Out-migrating Juvenile Salmonids in John Day Reservoir, Columbia River." *Transactions of the American Fisheries Society.* 120:405-420.

Pravecek, Jay and Keith A. Johnson. 1997. Research and Recovery of Snake River Sockeye Salmon Annual Report for April, 1995—April, 1996. Idaho Department of Fish and Game prepared for U.S. Department of Energy. Portland, Oregon. July 1997.

PSC (Pacific Salmon Commission). 1991. PSC Technical Advisory Committee Report.

Raymond, H.L. 1979. Effects of Dams and Impoundments on Migrations of Juvenile Chinook Salmon and Steelhead from the Snake River, 1966 to 1975. *Transactions of the American Fisheries Society.* 108(6): 505-529.

Raymond, H.L. and C. Sims. 1980. Assessment of Smolt Migration and Passage Enhancement Studies for 1979. Report to U.S. Army Corps of Engineers, Contract DACW-68-78-C-0051 and DACW-57-79-F-0411. National Marine Fisheries Service, Coastal Zone and Estuarine Studies Division, Seattle, Washington. 48 pp.

Reiman, B.E., R. Beamesderfer, S. Vigg, and T. Poe. 1991. "Estimated Loss of Juvenile Salmonids to Predation by Northern Squawfish, Walleyes, and Smallmouth Bass in John Day Reservoir, Columbia River." *Transactions of the American Fisheries Society.* 120: 448-458.

Rieman, B.E. and J.D. McIntyre. 1993. Demographic Habitat Requirements for Conservation of Bull Trout. USDA Forest Service. Intermountain Resarch Station. General Technical Report INT-302.

RMC and J.R. Skalski. 1994. Survival of Yearling Fall Chinook Salmon Smolts (*Oncorhynchus tshawytscha*) in Passage through and Kaplan Turbine at the Rocky Reach Hydroelectric Dam, Washington. Prepared for Public Utility District No. 1 of Chelan County, Wenatchee, Washington.

RMC, Mid Columbia Consulting Inc., and J.R. Skalski. 1994. Turbine Passage Survival of Spring Migrant Chinook Salmon (*Oncorhynchus tshawytscha*) at Lower Granite Dam, Snake River, Washington. Prepared for U.S. Army Corps of Engineers, Walla Walla District. Walla Walla, Washington.

Robberecht, R. 199?. Regeneration Potential of Vegetation on Newly Exposed Riverside Shorelines. Report submitted to U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington by Department of Range Resources, University of Idaho, Moscow, Idaho. 80pp.

Roby, D.D. and D.P. Craig. 1998. Avian Predation on Juvenile Salmonids in the Lower Columbia River 1997 Annual Report. Prepared for Bonneville Power Administration and U.S. Army Corps of Engineers. Corvallis, Oregon. September 1998.

Rocklage, A. and J. Ratti. 1998. Bird Studies Along the Lower Snake River. Prepared for the U.S. Army Corps of Engineers Walla Walla, Washington. Prepared by University of Idaho. Moscow, Idaho.

Rondorf, D.W., G.A. Gray, and R.B. Fairly. 1990. Feeding Ecology of Subyearling Chinook Salmon in Riverine and Reservoir Habitats of the Columbia River. *Transactions of the American Fisheries Society*. 19:16-24.

Ruby, R.H. and John A. Brown. 1992. A Guide to the Indian Tribes of the Pacific Northwest. Revised edition. University of Oklahoma Press. Norman, Oklahoma.

Sager, J.W. 1989a. Bonneville Dam. In: Engineering Geology in Washington, Vol. I. Washington Division of Geology and Earth Resource Bulletin 78. pp. 337-346.

Sager, J.W. 1989b. The Dalles Dam. In: Engineering Geology in Washington, Vol. I. Washington Division of Geology and Earth Resource Bulletin 78. pp. 347-352.

Sager, J.W. 1989c. John Day Dam. In: Engineering Geology in Washington, Vol. I. Washington Division of Geology and Earth Resource Bulletin 78. pp. 353-358.

Salo, E.O. 1991. Life History of Chum Salmon, *Oncorhynchus keta*. In: Groot, C. and L. Margolis (eds), Pacific Salmon Life Histories, p. 231-309. Univ. B.C. Press, Vancouver, B.C., Canada.

Schaller, H.A., C.E. Petrosky, and O.P. Langness. 1999. Contrasting Patterns of Productivity and Survival Rates for Stream-Type Chinook Salmon (*Oncorhynchus tshawytscha*) Populations of the Snake and Columbia Rivers. *Canadian Journal of Fisheries and Aquatic Science*. 56:1031-1045.

Schmitten, R. 1995. Proposed Recovery Plan for Snake River Salmon. Prepared for U.S. Department of Commerce, National Oceanic and Atmospheric Administration. March 1995.

Schmitz, R.A. and W.R. Clark. 1999. "Survival of Ring-necked Pheasant Hens during Spring in Relation to Landscape Features." *Journal of Wildlife Management*. 63(1):147-154. 8pp.

Schoeneman, D.E., R.T. Pressey, and C. Junge, Jr. 1961. Mortalities of Downstream Migrant Salmon at McNary Dam. Transactions of the American Fisheries Society 90:58-72.

Schrank, B.P., B.A. Ryan, and E.M. Dawley. 1996. Evaluation of the Effects of Dissolved Gas Supersaturation on Fish and Invertebrates in Priest Rapids Reservoir, and Downstream from Bonneville and Ice Harbor Dams, 1995. Report to the U.S. Army Corps of Engineers. Contract E96940029. Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, Washington 98112-2097.

Schrank, B.P., B.A. Ryan, and E.M. Dawley. 1997. Evaluation of the Effects of Dissolved Gas Supersaturation on Fish and Invertebrates in Priest Rapids Reservoir and Downstream from Bonneville and Ice Harbor Dams, 1995. Report to the U.S. Army Corps of Engineers. Contract E96940029. 45 p. Available from Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration. Seattle, Washington.

Schrank, B.P., B.A. Ryan, and E.M. Dawley. 1998. Evaluation of the Effects of Dissolved Gas Supersaturation on Fish Residing in the Snake and Columbia Rivers, 1996. Coastal Zone and Estuarine Studies Division, Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration. Seattle, Washington. March 1998.

Schreck, C. and J. Congleton. 1994. Evaluation of Facilities for Collection, Bypass and Transportation of Outmigrating Salmonids. Abstract. In: U.S. Army Corps of Engineers, 1994 Annual Research Review: Fish Passage Development and Evaluation Program. U.S. Army Corps of Engineers, Walla Walla District. Walla Walla, Washington.

Schreck, C.B. and T.P. Stahl. 1999. Evaluation of Migration and Survival of Juvenile Salmonids Following Transportation, Draft Annual Report for 1998. Corvallis, Oregon. 1999.

Schreck, C.B., L.E. Davis, D. Kelsey, J.L. Congleton, and W.J. LaVoie. 1998. Evaluation of Facilities for Collection, Bypass, and Transportation of Outmigrating Chinook Salmon, 1995 Annual Report (Draft). May 1998.

Schuck, M.L. 1992. Observations on the Effects of Reservoir Drawdown on the Fishery Resource Behind Little Goose and Lower Granite Dams March, 1992. Report #92-13. Washington Department of Fish and Wildlife. Olympia, Washington. 18 pp.

Schuck, M.L. and H.T. Kurose. 1992. South Fork Toutle River Fish Trap Operation and Salmonid Investigations, 1981-1982. Final Report submitted to the U.S. Army Corps of Engineers. Portland District. Portland, Oregon.

Scott, W.B. and E.J. Crossman. 1973. Freshwater Fishes of Canada. Bulletin 184, Fish. Res. Bd. of Canada, Ottawa.

Servizi, J.A. and D.W. Martens. 1987. Some Effects of Suspended Fraser River Sediments on Sockeye Salmon (*Oncorhynchus nerka*). Department of Fisheries and Oceans, Fisheries Research Branch, Cultus Lake Salmon Research Laboratory, Cultus Lake, British Columbia, Canada.

Sherwood, CR., D.A. Jay, R.B. Harvey, P. Hamilton, and C.A. Simenstadt. 1990. "Historical Changes in the Columbia River Estuary." *Progressive Oceanography*. 25:229-352.

Sims, C., A. Giorgi, R. Johnsen, and D. Brege. 1983. Migrational Characteristics of Juvenile Salmon and Steelhead in the Columbia Basin, 1982. Final Report to the U.S. Army Corps of Engineers, National Oceanic and Atmospheric Administration, National Marine Fisheries Services. 35 p. plus Appendices.

Sims, C.W. and F.J. Ossiander. 1981. Migration of Juvenile Chinook Salmon and Steelhead in the Snake River, from 1973 to 1979, A Research Summary. Final Report. Contract No. DACW68-78-C-0038. Prepared for U.S. Army, Corps of Engineers, Walla Walla, Washington. 31 pp.

Smith, M.R., P.W. Mattocks, Jr., and K.M. Cassidy. 1997. Breeding Birds of Washington State. Volume 4 in Washington State Gap Analysis—Final Report. Seattle Audubon Society Publications in Zoology No. 1, Seattle, Washington. 538 pp.

Smith, S.G. and J. Williams. 1999. NMFS Methods for Estimating Survival through the Hydrosystem 1966-1980 and 1993-1998. Manuscript, March 11, 1999. Northwest Fisheries Science Center, National Marine Fisheries Service. Seattle, Washington. 11 p.

Smith, S.G. and Other Authors. 1998. Draft Report of 1998 Smolt Survival Studies. National Marine Fisheries Service. Seattle, Washington.

Spurgeon, W., D. Hurson, T. Wik, M. Halter, D. Ross, P. Verhey, R. Baxter, M. Jensen, J. Kamps, P. Wagner, M. Price, S. Lind, M. Plummer, B. Eby, P. Hoffarth, P. Tudor, and S. Caromile. 1997. Juvenile Fish Transportation Program 1996 Annual Report. Walla Walla District, U.S. Army Corps of Engineers. Walla Walla, Washington.

Stalmaster, M.V. 1976. Winter Ecology and Effects of Human Activity on Bald Eagles in the Nooksack River Valley, Washington. M.S. Thesis. Western Washington State College. 100 pp.

State of Oregon, Office of Economic Analysis, Department of Administrative Services. 1997. County Population Forecasts. Accessed at: http://www.oea.das.state.or.us/county/co_pop.htm

State of Washington, Office of Financial Management. 1999. Washington State County Population Projections by Age and Sex: 1990-2020. Accessed at: http://www.ofm.wa.gov/pop902020.

Steward, Cleveland R. 1994. Assessment of the Flow-Survival Relationship Obtained by Sims and Ossiander (1981) for Snake River Spring/Summer Chinook Salmon Smolts. Prepared for U.S. Department of Energy, Bonneville Power Administrations, Division of Fish and Wildlife. Portland, Oregon. April 1994.

Stober, Q.J., M.R. Griben, R.V. Walker, A.L. Setter, I. Nelson, J.C. Gislason, R.W. Tyler, and E.O. Salo. 1979. Columbia River Irrigation Withdrawal Environmental Review: Columbia River Fishery Study. Final Report FRI-UW-7919 to U.S. Army Corps of Engineers.

Stocker, M. and D. Peacock (Eds). 1998. Report of the PSARC Salmon Subcommittee Meeting April 27 – May 1, 1998. Fisheries and Oceans Canada, Prince Rupert, BC. V8J 1GB.

Stroud, R.K., G.R. Bouck, and A.V. Nebeker. 1975. Pathology of Acute and Chronic Exposure of Salmonid Fishes to Supersaturated Water. In: W.A. Adams (ed.), pp. 435-489. Chemistry and Physics of Aqueous Gas Solutions. The Electrochemical Society. Princeton, New Jersey.

Sullivan, K., T.E. Lisle, C.A. Dollof, G.E. Grant, and L.M. Reid. 1987. Stream Channels: The Link Between Forests and Fishes. Pages 98-142 in E.O. Salo and T.W. Cundy (editors). Streamside Management: Forestry and Fisheries Interaction. Control Number 57, Institute of Forest Resources, University of Washington. Seattle, Washington

Taki, D. and A. Mikkelsen. 1997. Snake River Sockeye Salmon Habitat and Limnological Research. Prepared by the Shoshone-Bannock Tribes, Fort Hall, Idaho for the Bonneville Power Administration, Portland, Oregon. Project No. 91-71. April 1997.

Taylor, D.M. and C.H. Trost. 1992. "Use of Lakes and Reservoirs by Migrating Shorebirds in Idaho." *Great Basin Naturalist.* 52(2):179-184.

Taylor, G.H. and C. Southards. 1997. Long-term Climate Trends and Salmon Population. Oregon Climate Service, Oregon State University. Corvallis, Oregon.

Thomas, J.W. (ed.). 1979. Wildlife Habitats in Managed Forests in the Blue Mountains of Oregon and Washington. Agricultural Handbook No. 553. USDA Forest Service. 512 pp.

Thompson, D.Q. 1989. Control of Purple Loosestrife. U.S. Fish and Wildlife Service, Fish and Wildlife Leaflet 13. Washington, D.C. 6 pp.

Toner, M.A. and E.M. Dawley. 1995. Evaluation of the Effects of Dissolved Gas Supersaturation on Fish and Invertebrates Downstream from Bonneville Dam, 1993. Prepared for U.S. Army Corps of Engineers. Contract No. E96930036. 39 p. Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, Washington 98112-2097.

Toner, M.A., E.M. Dawley, and B.A. Ryan. 1995. Evaluation of the Effects of Dissolved Gas Supersaturation on Fish and Invertebrates Downstream from Bonneville, Ice Harbor, and Priest Rapids Dams, 1994. Report to the U.S. Army Corps of Engineers. Contract E96940029. 43 p. Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, Washington 98112-2097.

Turner, R., J.R. Kuskie, Jr., and K.E. Kostow. 1983. Evaluations of Adult Fish Passage at Little Goose and Lower Granite Dams, 1981. U.S. Army Corps of Engineers, Portland District. Portland, Oregon.

TVA and Marshall University. 1998. The Incremental Cost of Transportation Capacity in Freight Railroading: An Application to the Snake River Basin. The Tennessee Valley Authority and the Center for Business and Economic Research, Lewis College of Business, Marshall University. July 1998.

U.S. Bureau of Economic Analysis (U.S. Department of Commerce, Bureau of Economic Analysis). 1999. Regional Economic Informational System, 1969-1997. Accessed at: http://fisher.lib.virginia.edu/reis/.

U.S. Census Bureau (U.S. Department of Commerce, Bureau of the Census). 1970, 1980, 1990. U.S. Government Printing Office. Washington D.C.

U.S. Census Bureau. 1992. Census for Agriculture. Accessed at: http://www.census.gov.

University of Idaho, Agricultural Enterprises, Inc., and Normandeau Associates. 1998. Sport Fishery Use and Value on Lower Snake River Reservoirs. Phase I Report: Volume 2 of 2, Reservoir Sport Fishery during 1997. Draft Report. Contract number DACW69-96-D-003. Prepared for the U.S. Army Corps of Engineers, Walla, Walla, Washington. 76 pp.

USDA Forest Service and BLM (U.S. Department of Agriculture, Forest Service and U.S. Department of the Interior, Bureau of Land Management). 1997. Interior Columbia Basin Ecosystem Management Project. Eastside Environmental Impact Statement, Volume 1.

USDA Forest Service and BOR (USDA Forest Service and U.S. Department of the Interior Bureau of Reclamation). 1997. Interior Columbia Basin Ecosystem Management—Eastside EIS: http://www.icbemp.gov/html/east_eis.html—Upper Columbia River EIS: http://www.icbemp.gov/html/ucrb_eis.html.

USFWS (U.S. Fish and Wildlife Service). 1999. Endangered and Threatened Wildlife and Plants; Final Rule to List the Plant Thelypodium Howellii ssp. Spectabilis (Howell's Spectacular Thelypody) as Threatened. Federal Register 64(101):28393-28403.

USFWS. 1998a. Fish and Wildlife Coordination Act Report for the U.S. ACOE Lower Snake River Juvenile Salmon Migration Feasibility Study—Draft. U.S. Fish and Wildlife Service, Upper Columbia River Basin Office, Columbia River Fisheries Program Office, Idaho Fishery Resource Office. 220pp.

USFWS. 1998b. Draft EIS on the Reintroduction of Grizzly Bears into the Bitterroot Ecosystem. U.S. Fish and Wildlife Service.

USFWS. 1998c. Idaho Wolf Update–October 19, 1998. U.S. Fish and Wildlife Service, Snake River Basin Office. Posted on the Internet at: http://www.fws.gov/r1srbo/SRBO/Wolf_upd.htm

USFWS. 1998d. Endangered and Threatened Wildlife and Plants: Proposal to List the Contiguous United States Distinct Population Segment of the Canada Lynx; Proposed Rule. Federal Register 63(130):36993-37013.

USFWS. 1998e. Listed and Proposed Endangered and Threatened Species and Species of Concern which may Occur in the Vicinity of the Primary and Secondary Impact Areas of the Lower Snake River Feasibility Study. FWS Reference: 1-9-99-SP-040, & 1-4-99-SP-24. December 3, 1998.

USFWS. 1997. Wildlife Monitoring Study of the John Day Pool from 1994-1996. Unpublished Report. Mid-Columbia River Refuge Complex, U.S. Fish and Wildlife Service, Umatilla, Oregon.

USFWS. 1996. Final Rule; Reclassification of Mirabilis Macfarlanei (MacFarlane's four-o'clock) from Endangered to Threatened Status. 50 CFR Part 17, March 15, 1996.

USFWS. 1995. Final Report for the HSI Validation Study for the Lower Snake River Fish and Wildlife Compensation Plan. Prepared for the U.S. Army Corps of Engineers, Walla Walla District.

USFWS. 1994a. Final Rule Determining the Plant, Water Howellia (*Howellia aquatilis*), to be A Threatened Species. 50 CFR Part 17, July 14, 1994.

USFWS. 1994b. Final Rule Establishing a Nonessential Experimental Population of Gray Wolves in Yellowstone National Park in Wyoming, Idaho, Montana, Central Idaho and Southwestern Montana. Federal Register, Volume 59, November 22, 1994.

USFWS. 1993. Grizzly Bear Recovery Plan. Missoula, Montana. 181 pp.

USFWS. 1992. Endangered and Threatened Wildlife and Plants: Final Rule to List the Plant *Spiranthes diluvialis* (Ute ladies' tresses) as a Threatened Species. Federal Register 57(12):2048-2054.

USFWS. 1991. Special Report—Lower Snake River Fish and Wildlife Compensation—Wildlife Compensation Evaluation for the Lower Snake River Project, U.S. Fish and Wildlife Service, Boise, Idaho, U.S. Army Corps of Engineers, Walla Walla, Washington and Washington Department of Wildlife. Pasco, Washington. 59 pp.

USFWS. 1987. Northern Rocky Mountain Wolfe Recovery Plan. U.S. Fish and Wildlife Service. Denver, Colorado. 119pp.

USFWS. 1986. Pacific Bald Eagle Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon. 160 pp.

USFWS. 1978. Supplemental Enhancement Report to the Corps of Engineers for the 1972 Mitigation Report "A Special Report on the Lower Snake River Dams, Washington and Idaho." U.S. Fish and Wildlife Service. Olympia, Washington.

Van Hyning, J.M. 1968. Factors Affecting the Abundance of Fall Chinook Salmon in the Columbia River. Oregon State University, Ph.D. Thesis, 424 p.

Vigg, S.t., P. Poe, L.A. Prendergast, and H.C. Hansel. 1991. Rates of Consumption of Juvenile Salmonids and Alternative Prey Fish by Northern Squawfish, Walleyes, Smallmouth Bass, and Channel Catfish in John Day Reservoir, Columbia River. *Transactions of the American Fisheries Society*. 120:421-438.

WA DNR (Washington Department of Natural Resources). 1997. Board Manual: Standard Methodology for Conducting Watershed Analysis Under Chapter 222-22 WAC. Washington Forest Practices Board. Version 4.0. November.

Wahlers, R. 1998. Agricultural Workforce in Washington State 1997. Washington State Employment Security, Labor Market and Economic Analysis Branch.

Wallen, E.I. 1951. The Direct Effect of Turbidity on Fishes. Oklahoma Agricultural and Mechanical College, Arts and Sciences Studies, Biological Series 48(2).

Wantanabe, M. and T. Nitta. 1999. Abrupt Shifts in the Atmospheric Circulation and Associates Decadal Climate Variations in the Northern Hemisphere Winter: A Diagnostic Study. J. Climate.

Waples, R.S. 1991. Pacific Salmon, *Oncorhynchus* spp., and the Definition of "Species" Under the Endangered Species Act. In: Marine Fisheries Review Vol. 53, No. 3.

Waples, R.S., R.P. Jones, Jr., B.R. Beckman, and G.A. Swan. 1991. Status Review for Snake River Fall Chinook Salmon. National Marine Fisheries Service. Seattle, Washington. 73 p.

Ward, D.L., R.R. Boyce, F.R. Young, and F.E. Olney. 1997. "A Review and Assessment of Transportation Studies for Juvenile Chinook Salmon in the Snake River." *North American Journal of Fisheries Management.* 17:652-662.

Ware, J.A. 1989. Archaeological Inundation Studies: Manual for Reservoir Managers. U.S. Army Corps of Engineers, Contract Report EL-89-4.

Washington Department of Fisheries. 1994. Upstream Passage, Spawning, and Stock Indentification of Fall Chinook Salmon in the Snake River. 1992. Annual Report FY 92-93. Eds. H.L. Blankenship and G. W. Mendel. Prepared for U.S. Department of Energy Bonneville Power Administration, Division of Fish and Wildlife. Project No. 92-046. February 1994.

Washington State Department of Transportation. 1997. 1997 Annual Traffic Report. Washington State Department of Transportation.

WDFW (Washington Department of Fish and Wildlife) and Western Washington Treaty Indian Tribes. 1998. Washington State Salmonid Stock Inventory. Appendix Bull Trout and Dolly Varden. Washington Department of Fish and Wildlife. Olympia, Washington.

WDFW (Washington Department of Fish and Wildlife). 1999a. Management Recommendations for Washington's Priority Species, Volume IV: Birds. Priority Habitats and Species Program, Washington Department of Fish and Wildlife, Olympia, Washington. Accessed through Internet at: http://www.wa.gov/wdfw/hab/phs/vol4/birdrecs.htm

WDFW. 1999b. Washington Department of Fish and Wildlife List of Candidate Species. Accessed at: http://www.wa.gov/wdfw/wlm/diversty/soc/candidat.htm

WDG (Washington Department of Game). 1984. Status Report on Wildlife Mitigation: Lower Snake River Project. Report prepared for Bonneville Power Administration by Washington Department of Game and U.S. Fish and Wildlife Service. Section L.

WDW (Washington Department of Wildlife). 1993. Status of the North American lynx (Lynx canadensis) in Washington. Unpublished Report. Washington Department of Wildlife. Olympia, Washington. 101 pp.

Weber, J.W. and E.J. Larrison. 1977. Birds of Southeastern Washington. University of Idaho Press. Moscow, Idaho.

Weber, K.G. 1954. Testing the Effect of a Bonneville Draft Tube on Fingerling Salmon. U.S. Fish and Wildlife Service. Seattle, Washington.

Weitkamp, D.E. and M. Katz. 1980. A Review of Dissolved Gas Supersaturation Literature. Transactions of the American Fisheries Society. 109:659-702.

Welch, D. 1999. NW Fishletter. NWWF.075/Feb.09.1999. @ http://www.newsdata.com/enernet/fishletter/fishltr75.html.

Welch, D.W., B. Ward, B. Smith, and J. Eveson. In Press. Influence of the 1989/90 Ocean Climate Shift on British Columbia Steelhead *(Oncorhynchus mykiss)* Populations. Fisheries Oceanography.

White, Robert G., Glenn Phillips, George Liknes, Jim Brammer, William Connor, Larry Fidler, Tommy Williams, and W. Patrick Dwyer. 1991. Effects of Supersaturation of Dissolved Gases on the Fishery of the Bighorn River Downstream of the Yellowtail Afterbay Dam. Prepared for U.S. Department of the Interior, Bureau of Reclamation, Missouri Basin, Region 6. April 1991.

Wik, S.J., A.L. Shoulders, L.A. Reese, D.F. Hurson, T.D. Miller, L.L. Cunningham, J.P. Leier, L.E. Mettler, P.F. Poolman, J.A. Buck, C.A. Wolff, and J.S. Smith. 1993. 1992 Reservoir Drawdown Test, Lower Granite and Little Goose Dams. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Williams, J., G. Matthews, J. Myers, S.G. Smith, and C. Toole. 1998b. Estimate of SARs of Snake River Spring Chinook Salmon. Submission 9 to the PATH Weight of Evidence Report. Appendices.

Williams, J., G. Matthews, J. Myers, S.G. Smith, T. Cooney, and C. Toole. 1998a. Hatchery "Extra Mortality" Hypothesis. Submission 1 to the PATH Weight of Evidence Report. Appendices.

Williams, J.G. and G.M. Matthews. 1995. A Review of Flow and Survival Relationships for Spring and Summer Chinook Salmon, *Oncorhynchus tshawytscha*, from the Snake River Basin. Fisheries Bulletin, U.S. 93:732-740. Bethesda, Maryland.

Williams, J.G. and T.C. Bjornn (Eds.). 1998. Fall Chinook Salmon Survival and Supplementation Studies in the Snake River and Lower Snake River Reservoirs, 1996. Prepared for U.S. Department of Energy and Bonneville Power Administration.

Williams, J.G., G.M. Matthews, and J.M. Myers. 1997. The Columbia River Hydropower System: Does It Limit Recovery of Spring/Summer Chinook Salmon? (Draft Report). NOAA, Coastal Zone and Estuarine Studies Division, National Marine Fisheries Service. Seattle, Washington.

Williams, R.N. and 12 Coauthors. 1999. Scientific Issues in the Restoration of Salmonid Fishes in the Columbia River. *Fisheries*. 24:10-19.

Wittinger, Rod, John Ferguson, and Thomas Carlson. 1995. Proceedings, Turbine Fish Passage Survival Workshop May 31 to June 1, 1995. Sponsored by U.S. Army Corps of Engineers. Portland, Oregon. October 1995.

Wood, C.M. 1995. Fulfilling the Executive's Trust Responsibility Toward the Native Nations on Environmental Issues: A Partial Critique of the Clinton Administration's Promises and Performance. In: Environmental Law, Vol. 25, No. 3, pp. 733-800.

WRC (U.S. Water Resources Council). 1983. Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies.

Wydoski, R.S. and R.R. Whitney. 1979. Inland Fishes of Washington. University of Washington Press, Seattle, Washington. 220 pp.

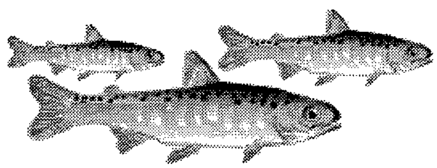
Yearsley, J. 1999. Columbia River Temperature Assessment Simulation Methods. EPA Region 10 Draft Review Report. Seattle, Washington.

Yocum, C.F. 1961. Recent Changes in Canada Goose Populations in Geographical Areas in Washington. Murrelet. 42:13-21.

Young, M.K., W.A. Hubert, and T.A. Wesche. 1991. "Selection of Measures of Substrate Composition to Estimate Survival to Emergence of Salmonids and to Detect Changes in Stream Substrates." *North American Journal of Fisheries Management.* 11: 339346.

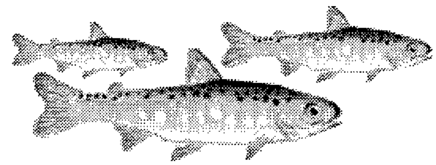
Zimmerman, M.A. and L.A. Rasmussen. 1981. Juvenile Salmonid Use of Three Columbia River Backwater Areas Proposed for Subimpoundment. U.S. Fish and Wildlife Service, Portland Field Office. Portland, Oregon. 27 pp.

Zimmerman, M.P. and R.M. Parker. 1995. "Relative Density and Distribution of Smallmouth Bass, Channel Catfish, and Walleye in the Lower Columbia and Snake Rivers." *NW Science.* 69:19-28.



Chapter 11

Glossary



11. Glossary

A-race/B-race—Terms related to timing and distribution of adult steelhead in the Columbia River System. A-race refers to those summer steelhead that enter the Columbia River in early August and are destined for tributaries throughout the Columbia. B-race refers to those that enter in late August through October and are destined primarily for tributaries of the Snake River.

Aesthetics—Of or pertaining to the sense of beautiful.

Algae—Photosynthetic organisms lacking multicellular sex organs.

Agricultural land tenure—Land owned, used, or held for agricultural purposes.

Alternative 1—Existing Conditions—The existing hydrosystem operations under the National Marine Fisheries Service's 1995 and 1998 Biological Opinions. The Corps would continue to increase spill and manipulate spring and summer river flows as much as possible to assist juvenile salmon and steelhead migration. Juvenile salmon and steelhead would continue to pass the dams through the turbines, over spillways, or through the fish bypass systems. Transportation of juvenile fish via barge or truck would continue at its current level.

Alternative 2—Maximum Transport of Juvenile Salmon—The existing hydrosystem operations plus maximum transport of juvenile salmon, without surface bypass collectors. The number of juvenile fish transported via barge or truck would be increased to the maximum extent possible.

Alternative 3—Major System Improvements—The existing hydrosystem operations and maximum transport of juvenile salmon, but with additional major system improvements (such as surface bypass collectors) that could be accomplished without dam breaching.

Alternative 4—Dam Breaching—Natural river drawdown of the four lower Snake River reservoirs.

Ambient air quality standards (AAQSs)—Standards required by the Federal Clean Air Act and enforced by the U.S. Environmental Protection Agency that protect public health, provide for the most sensitive individuals, and allow a margin of safety by setting an acceptable level for measured pollutant concentrations. AAQSs cannot take into account the cost of achieving the standards.

Anadromous fish—Fish, such as salmon or steelhead trout, that hatch in fresh water, migrate to and mature in the ocean, and return to fresh water as adults to spawn.

Assumption sets—When running the life-cycle model to generate future salmon population levels, several choices must be made regarding the magnitude of particular sources of mortality, routes of fish passage, flow rates, and so on. A complete set of these assumptions, used to generate 4,000 replicate Monte Carlo simulations of the effect of an alternative hydrosystem management action, is called an assumption set.

Average megawatt (aMW)—The average amount of energy (in megawatts) supplied or demanded over a specified period of time; equivalent to the energy produced by the continuous operation of one megawatt of capacity over the specified period.

Behavioral guidance structure (BGS)—A long, steel, floating structure designed to simulate the natural shoreline and guide fish toward the surface bypass collection system by taking advantage of their natural tendency to follow the shore.

Benthic community—Aquatic organisms and plants that live on the bottom of lakes or rivers, such as algae, insects, worms, snails, and crayfish. Benthic plants and organisms contribute significantly to the diets of many reservoir fish species.

Bacterial Kidney Disease (BKD)—A disease of salmonids caused by the bacterium *Renibacterium salmoninarum.* The bacterium can be passed between juvenile fish where they are concentrated in hatcheries and in transportation systems and can be passed to the next generation by an infected female.

Bulkhead channel—Channel through which fish are carried upward through the turbines via a bulkhead slot if they are not diverted by turbine intake screens.

Bypass channel—Fish diverted from turbine passage are directed through a bypass channel to a holding area for release or loading onto juvenile fish transportation barges or trucks.

Class 1 River—The largest rivers of the state, such as the Skagit, Nooksack, Chehalis, etc.

Collection channel—Holding area within the powerhouse that fish enter after exiting the bulkhead slot.

Columbia-Snake Inland Waterway—456-mile long water highway formed by the eight mainstem dams and lock facilities on the lower Columbia and Snake rivers.

Commodity—A transportable article of trade or commerce, especially an agricultural or mining product.

Community resiliency—A town's ability to successfully deal with multiple social and economic changes; a primary indicator of a community's health and vitality.

Conversion rates—The estimated survival of adults during upstream migration is expressed as a "conversion rate." Conversion rates are calculated by dividing the count of a particular group of adult fish at the uppermost dam by the count of that group at the lowest dam, subtracting out estimates of harvest and tributary harvest between the dams.

CRiSP—Acronym for Columbia River Salmon Passage, the passage model developed by the Center for Quantitative Studies at the University of Washington under contract to the Bonneville Power Administration.

CRITFC Tribes—Members of the Columbia River Intertribal Fish Commission include the Nez Perce Tribe, the Confederated Tribes of the Umatilla Indian Tribes, the Yakama Indian Nation, and the Confederated Tribes of the Warm Springs of Oregon.

Cultural resources—Archaeological and historical sites, historic architecture and engineering, and traditional cultural properties.

Decommission—To take the dams and associated facilities out of service such that they are not in use or working condition.

Dam breaching—In the context of this FR/EIS, dam breaching involves removal of the earthen embankment section at Lower Granite and Little Goose, and formation of a channel around Lower Monumental and Ice Harbor.

Deflation—The removal of the archaeological soils by water, leaving heavier items and artifacts in place, but dispersing lighter artifacts.

Differential delayed transportation mortality—Additional mortality suffered by transported fish after their release from the transport vehicle into the Columbia River below Bonneville Dam—hypothesized to be caused by stresses associated with the transportation system. Differential mortality is measured as the ratio of the post-Bonneville-Dam survival of transported fish to that of nontransported fish. Delayed transportation mortality is differentiated from any direct mortality of fish that occurs during transportation.

Direct service industries (DSIs)—Some of the region's largest industries (e.g., aluminum companies) who buy their power directly from the Bonneville Power Administration.

Dissolved gas supersaturation—Caused when water passing through a dam's spillway carries trapped air deep into the waters of the plunge pool, increasing pressure and causing the air to dissolve into the water. Deep in the pool, the water is "supersaturated" with dissolved gas compared to the conditions at the water's surface.

Drawdown Regional Economic Workgroup (DREW)—A group of regional economists studying the economic issues associated with alternative actions on the lower Snake River.

Drawdown—In the context of this FR/EIS, drawdown means returning the lower Snake River to its natural, free-flowing condition via dam breaching.

D-values—Measure used to quantify differential delayed transportation mortality. A D-value of 1.0 would mean that there was no differential delayed transportation mortality (there could be mortality; it is just no different between transported and non-transported fish). The lower the value of D (relative to 1.0), the larger the differential delayed transportation mortality. It is possible for D to be greater than 1 (in which case transported fish would have survived at a higher rate than non-transported fish).

Economic diversity index—Provides a relative indication of the economic opportunities present in a community.

Endangered species—A native species found by the Secretary of the Interior to be threatened with extinction.

Evapotranspiration—Discharge of water from the earth's surface to the atmosphere by evaporation from lakes, streams, and soil surfaces and by transpiration from plants. Also know as total evaporation, water loss.

Endemic—A term used to describe a species whose population is limited to one area.

Environmental justice—The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income within the development, implementation, and enforcement of environmental laws.

Evolutionary Significant Unit (ESU)—A population that 1) is substantially reproductively isolated from conspecific populations and 2) represents an important component of the evolutionary legacy of the species.

Extra mortality—Any mortality occurring outside the migration corridor (i.e., below Bonneville Dam) that is not accounted for by in-common climate effects or by differential delayed transportation mortality.

Fallback—Adult fish that successfully pass upstream of a dam, but are either swept or swim through the spillway, turbines, or navigation locks to below the dam.

Fauna—A general term for animal life.

Federal Columbia River Power System—Official term for the 14 Federal dams on the Columbia and Snake rivers.

Firm energy load-carrying capability (FELCC)—The amount of energy the region's generating system, or an individual utility or project, can be called on to produce on a firm basis during actual operations. FELCC is made up of both hydro and non-hydro resources, including power purchases.

Firm energy—The amount of energy that can be generated given the region's worst historical water conditions. It is energy produced on a guaranteed basis.

Fish collection/handling facility—Holding area where juvenile salmon and steelhead are separated from adult fish and debris by a separator and then passed to holding ponds or raceways until they are loaded onto juvenile fish transportation barges or trucks.

Fish guidance efficiency (FGE)—Percent of juvenile salmon and steelhead diverted away from the turbines by submersed screens or other structures.

Fish passage efficiency (FPE)—Portion of all juvenile salmon and steelhead passing a facility that do not pass through the turbines.

Flow augmentation—Increasing river flows above levels that would occur under normal operation by releasing more water from storage reservoirs upstream.

FLUSH—Acronym for Fish Leaving Under Several Hypotheses, the passage model developed by the states of Oregon, Washington, and Idaho and the Columbia River Intertribal Fish Commission.

Foraging habitat—Areas where wildlife search for food.

Fugitive emissions—Material released into the air from sources other than industrial vents and stacks (e.g., windblown dust).

Gas bubble disease or trauma—Condition caused when dissolved gas in supersaturated water comes out of solution and equilibrates with atmospheric conditions, forming bubbles within the tissues of aquatic organisms. This condition can kill or harm fish.

Habitat—An area that provides some portion of the requirements for the life history of a given species.

Habitat management units (HMUs)—62 parcels of land scattered along the river and reservoirs that the Corps purchased and manages as mitigation for the land that was inundated as a result of the dams and reservoirs. These HMUs are managed to replace hunting, fishing, and recreation opportunities lost as a result of inundation as well as to benefit and provide for wildlife that lost habitat to inundation.

Headburn—A condition where open wounds are found on adult fish heads.

Hunter use-day—Unit of measurement used in recreation section that refers to one day of hunting by one person.

Hydrographs—A graphic representation of stage, flow, velocity, or other characteristics of water at a given point and time.

Hydrology—The science dealing with the continuous cycle of evapotranspiration, precipitation, and runoff.

Inundation—The covering of pre-existing land and structures by water.

Irrigation—Artificial application of water to usually dry land for agricultural use.

Jack salmon—A precocious or early maturing salmonid fish; most are males.

Juvenile fish transportation system—System of barges and trucks used to transport juvenile salmon and steelhead from the lower Snake River or McNary Dam to below Bonneville Dam for release back into the river; alternative to in-river migration.

Littoral zone—The shore area along a body of water, usually a lake, down to the depth of 10 meters.

Lock—A chambered structure on a waterway closed off with gates for the purpose of raising or lowering the water level within the lock chamber so ships can move from one elevation to another along the waterway.

Lower Snake River Hydropower Project—The four hydropower facilities operated by the Corps on the lower Snake River: Lower Granite, Little Goose, Lower Monumental, and Ice Harbor.

Macroinvertebrates—An arbitrary term used to refer to invertebrates large enough to be seen with the naked eye.

Macrophytes—large, vascular aquatic plants that grow in shallow water along the shorelines of lakes or in the slow-moving reaches of rivers.

Megawatt (MW)—One million watts, a measure of electrical power or generating capacity. A megawatt will typically serve about 1,000 people. The Dalles Dam produces an average of about 1,000 megawatts.

Mesic shrubland—Wetlands usually found in side canyons and seasonal springs and seeps, characterized by species such as netleaf hackberry, Douglas hawthorn, smooth sumac, blackberry, and rose.

Minimum operating pool (MOP)—The bottom one foot of the operating range for each reservoir. The reservoirs normally have a 3-foot to 5-foot operating range.

Mitigation—To moderate or compensate for an impact or effect.

Natal—Stream of origin.

Navigation—Method of transporting commodities via waterways; usually refers to transportation on regulated waterways via a system of dams and locks.

Nonattainment areas—Geographic areas with measured pollutant concentrations greater than the AAQSs.

Ocean regime shift—Cycle of oceanographic conditions that alters patterns of circulation, the distribution of predators and prey, and productivity. Cycles have been observed on the timescale of years (El Niño), decades (Pacific interdecadal oscillations), and thousands of years (ice ages). The current ocean regime, and a shift on the timescale of years or decades, may affect the likelihood of recovery under any hydrosystem management alternative.

Palustrine emergent—Relatively uncommon wetland type characterized by cattail, bulrushes, and sedges.

Palustrine forest—Wetlands found adjacent to the reservoirs and major tributaries characterized by cottonwood, alder, and black locust.

Palustrine open water—Wetland type characterized by open water such as ponds.

Palustrine scrub-shrub—Wetlands found adjacent to river and on islands characterized by shrubs such as willow.

Passage model—Mathematical simulation of the effect of downstream passage (through eight Federal mainstem hydro projects) on the survival of juvenile salmonids. PATH used two passage models, CRiSP and FLUSH (see above). The models differ both in their mathematical structure and in assumptions about survival through various parts of the hydrosystem (see page 25 in Marmorek and Peters [1998] *[March 1998 report]* for a brief comparison).

Pelagic food sources—Food sources for aquatic organisms that live in the water column.

Per capita income—Average income per person.

pH—An index of the hydrogen ion concentration in water, measured on a scale of 0 to 14. A value of 7 indicates a neutral condition, values less than 7 indicate acidic conditions, and values greater than 7 indicate alkaline conditions.

Photic—Relating to light.

Photoperiod—Length of the period of daylight each day.

Photosynthesis—Biochemical process by which plants use the energy of sunlight to combine carbon dioxide and water into sugars.

Phytoplankton—Drifting plants such as microscopic algae that nourish themselves from the energy of the sun; they are at the base of the food chain and provide a food source for bacteria, water molds, and zooplankton. Plankton that demonstrate characteristics of the plant kingdom (i.e., they derive energy from inorganic substances).

Piping—Soil erosion process in which the pore pressure increases cause a vertical type fracture in the soil; this process can be a precursor to larger mass wasting failures.

Plan for Analyzing and Testing Hypotheses (PATH)—A work group of regional fisheries biologists that measure projected salmon and steelhead survival rates associated with alternative actions.

Plankton—The passively floating animal and plant life of a body of water.

Pumping stations—Facilities that draw water through intake screens in the reservoir and pump the water uphill to corresponding distribution systems for irrigation and other purposes.

Recovery—The process by which the ecosystem is restored so it can support self-sustaining and self-regulating populations of listed species as persistent members of the native biotic community. This process results in improvement in the status of a species to the point at which listing is no longer appropriate under the ESA.

Redd—A salmon or steelhead spawning nest in gravel in which eggs are deposited.

Reservoir fluctuation area—Area between the minimum and maximum pool levels of a reservoir which includes the littoral, wave-action, and inundation zones.

Resident fish—Fish species that reside in fresh water throughout their lifecycle.

Riparian—Ecosystem that lies adjacent to streams or rivers and is influenced by the stream and its associated groundwater.

Riparian area—Area including a stream channel, a lake, a pond, or wetland, and the adjacent land where the vegetation complex and microclimate conditions are products of the combined presence and influence of perennial and/or intermittent water, associated high water tables, and soils that exhibit some wetness characteristics.

Risk averse—In the context of PATH analyses, "risk averse" corresponds to a management action that minimizes the risk of not meeting recovery and survival criteria, an action that succeeds in satisfying performance criteria over the widest range of assumptions.

Rookery—A concentration of nesting birds, usually herons or pelicans.

Rule curves—Water levels, represented graphically as curves, that guide reservoir operations. See critical rule curves, energy content curves, and flood control rule curves.

Run-of-river—This describes hydropower facilities that do not have storage or the associated flood control capacity; run-of-river facilities essentially pass through as much water as they have coming in, either through the turbines or over the spillways.

Scouring—Concentrated erosive action, especially by stream or river water, as on the outside curve of a bend.

Simulated Wells Intake (SWI)—Modified turbine intake that draws water from below the surface so that the surface is calmer and juvenile fish are less influenced by turbine flows. This allows juvenile fish more opportunity to discover and enter the surface bypass collection system.

Slumping—A landslide; the separation of a land or soil mass from a land surface and its movement downslope.

Spawning—The reproductive process for aquatic organisms which involves producing or depositing eggs or discharging sperm.

Spill—Water released through the dam spillways, rather than through the turbines. Involuntary spill occurs when reservoirs are full and flows exceed the capacity of the powerhouse or power output needs. Voluntary spill is one method used to pass juvenile fish without danger of turbine passage.

Spillway flow deflectors (flip lips)—Structures that limit the plunge depth of water over the dam spillway, producing a less forceful, more horizontal spill. These structures reduce the amount of dissolved gas trapped in the spilled water.

Surface bypass collection (SBC) system—System designed to divert fish at the surface before they have to dive and encounter the existing turbine intake screens. SBCs direct the juvenile fish into the forebay, where they are passed downstream either through the dam spillway or via the juvenile fish transportation system of barges and trucks.

Surface erosion—Movement of soil particles down or across a slope, as a result to gravity and a moving medium such as rain or wind. The transport of sediment depends on the steepness of the slope, the texture and cohesion of the soil particles, the activity of rainsplash, sheetwash, gullying, dry ravel processes, and the presence of buffers.

Surficial deposits—Unconsolidated alluvial, residual, or glacial deposits overlying bedrock or occurring on or near the surface of the earth.

Survival—The species' persistence beyond the conditions leading to its endangerment, with sufficient resilience to allow for potential recovery from endangerment. The condition in which a species continues to exist into the future while retaining the potential for recovery.

Terracing—Creation of a relatively level bench or step-like surface, breaking the continuity of a slope.

Threatened species—A native species likely to become endangered within the foreseeable future.

Total suspended sediment (TSS)—The portion of the sediment load suspended in the water column. The grain size of suspended sediment is usually less than one millimeter in diameter (clays and silts). High TSS concentrations can adversely affect primary food production and fish feeding efficiency. Extremely high TSS concentrations can impair other biological functions such as respiration and reproduction.

Transponder—A transmitter-receiver used to track fish passage.

Transport to In-river Ratio (TIR)—The ratio of the number of adults returning to a given location from a transport group of marked juveniles to the number of adults returning to the same location from the "in-river" group of marked juveniles released to migrate downsteam in-river.

Trophic level—Position in the food chain determined by the number of energy-transfer steps to that level.

Tules—Fall chinook salmon that are confined mainly to the lower Columbia River tributaries (below Bonneville pool).

Turbidity—An indicator of the amount of sediment suspended in water. It refers to the amount of light scattered or absorbed by a fluid. In streams or rivers, turbidity is affected by suspended particles of silts and clays, and also by organic compounds like plankton and microorganisms. Turbidity is measured in nephelometric turbidity units.

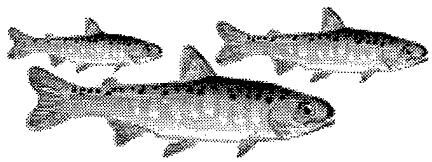
Turbine intake screens—Standard-length traveling fish screens or extended-length submerged bar screens that are lowered into the turbine bulkhead slots to divert fish from the turbine intake.

Turbine intakes—Water intakes for each generating unit at a hydropower facility.

Upriver brights—Fall chinook salmon that mainly spawn in the mainstem Columbia River in the Hanford Reach (downstream of Priest Rapids Dam) and in the Snake River System.

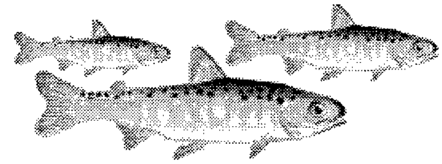
Wetland—An ecosystem in which groundwater saturates the surface layer of soil during a portion of the growing season, often in the absence of surface water. This water remains at or near the surface of the soil layer long enough to induce the development of characteristic vegetative, physical, and chemical conditions. Lands where saturation with water is the major factor in determining soil development and the types of plants that grow there.

Zooplankton—Tiny, floating animals that provide a food source for larger aquatic organisms such as snails and small fish. Plankton that demonstrate characteristics of the animal kingdom (i.e., they derive energy from organic matter).



Chapter 12

List of Preparers



12. List of Preparers

U.S. Army Corps of Engineers, Walla Walla District

Greg Graham, Civil Engineer—B.S. Civil Engineering
19 years of experience
Experience/Expertise: Civil Engineering Water Resource Planning, Water Resource Project Management
Role in EIS Process: Project Manager

Lonnie Mettler, Environmental Resource Planner—M.S. Wildlife Resources, B.S. Zoology
22 years of experience
Experience/Expertise: ESA Coordination, FWCA Coordination, Wildlife Ecology, and NEPA Document Preparation
Role in EIS Process: Lead Planner and Contracting Officers Representative

David Dankel, Environmental Resource Specialist—M.S. Natural Resource Communications, B.S. Forest Resources
25 years of experience
Experience/Expertise: Public Involvement and Natural Resource Environmental Interpretation
Role in EIS Process: Public Involvement Coordinator

Jeff Sedgwick, Environmental Engineer—B.S. Materials Science and Engineering, A.A.S. Environmental Technology
5 years of experience
Experience/Expertise: NEPA Document Preparation
Role in EIS Process: Assistant Planner

Anneli Aston, Environmental Resource Specialist—B.S. Environmental Policy
7 years of experience
Experience/Expertise: Environmental Resource Coordination and NEPA Compliance
Role in EIS Process: EIS Coordinator and Contract Administration

Mary Keith, Archaeologist—B.A. Anthropology
16 years of experience
Experience/Expertise: Plateau Cultural Area, Ethno-Archeology
Role in EIS Process: Cultural Resource Appendix, Tribal Coordination Appendix

Scott Ackerman, Wildlife Biologist—M.S. Geography, B.S. Wildlife Management
16 years of experience
Experience/Expertise: Terrestrial ESA Coordination, Mitigation Coordination, and FWCA Coordination
Role in EIS Process: Wildlife, Non Anadromous Fish ESA and CAR Manager

Rick Jones, General Biologist—M.S. Environmental Biology, B.S. Fish and Wildlife Management
25 years of experience
Experience/Expertise: Fisheries and Aquatic Ecology
Role in EIS Process: Anadromous Fish Appendix, Resident Fish Appendix, Water Quality Appendix, and Fluvial Geomorphology Appendix

Chris Pinney, Fishery Biologist—M.S. Aquatic Ecology, B.S. Zoology
16 years of experience
Experience/Expertise: Anadromous Fish Modeling and Anadromous Fish ESA Coordination
Role in EIS Process: Anadromous Fish Modeling, Anadromous Fish ESA

Tim Wik, Biologist—B.S. Aquatic Biology
Experience/Expertise: Fish Bypass at Mainstream Dams and Fish Culture Research
Role in EIS Process: Surface Bypass Collection

Steve Tatro, Civil Engineer, Technical Specialist—M.S. Civil Engineering, B.S. Civil Engineering
20 years of experience
Experience/Expertise: Concrete and Construction Materials Design, Concrete Construction, Project Engineering, and Technical Management
Role in EIS Process: Natural River Drawdown Engineering Appendix

Bruce Collision, Civil Engineer—B.S. Civil Engineering
20 years of experience
Experience/Expertise: Structural Design, Construction Contract Administration, and Engineering Technical Management
Role in EIS Process: Existing Systems and Major System Improvements Engineering Appendix

Dave Reese, Chief, Hydrology Branch—M.S. Civil Engineering, B.S. Civil Engineering
26 years of experience
Experience/Expertise: Hydrology, Hydraulics, Reservoir Regulation and Water Resources
Role in EIS Process: Hydrology/Hydraulics and Sedimentation Appendix

Nola Conway, Public Affairs Specialist—B.A. Journalism, B.S. Mass and Organizational Communication
18 years of experience
Experience/Expertise: Local, National, and Foreign Public Affairs and Media Outlets. Development and Coordination of Products for both Public and Media Audiences that Inform and Educate.
Role in EIS Process: Development of Media Communication Strategy

Clayton Garland, Realty Specialist—Certified Engineering Technician
34 years of experience
Experience/Expertise: Engineering, Contracting, and Real Estate
Role in EIS Process: Real Estate Appendix

Gary Ellis, Economics—M.B.A., B.S. Agricultural Economics
17 years of experience
Experience/Expertise: Incremental Cost Analysis/Environmental Projects, Flood Projects-Cost Benefits Analysis, Powerhouse Rehabilitation Projects, Cost Estimation, Navigation Reports, Flood Damage Reports to Congress, and Regional Input/Out Analysis
Role in EIS Process: Regional and Social Analysis

Gina Trafton, Regional Economist—B.S. Economics
12 years of experience
Experience/Expertise: Economic Analysis of Environmental Restoration (endangered species and habitat mitigation), Flood Control, Agricultural Projects, and Inland Navigation.
Role in EIS Process: Economic Appendix

John McKern, Chief, Fisheries Management Unit—M.S. Fisheries Science, B.S. Wildlife Science
Experience/Expertise: Fish Passage at Dams, Fish and Wildlife Mitigation
Role in EIS Process: Review and Input to Anadromous Fish Appendix, Review of all Appendices and Documents for Operations

Blaise Grden, Landscape Architect—Master Landscape Architecture, B.A. Geography
26 years of experience
Experience/Expertise: Landscape Architecture, Environmental Planning, and Geographic Information Systems
Role in EIS Process: Main Report GIS Plate Production and Snake River Maps Appendix

Phil Benge, Outdoor Recreation Planner—B.S. Natural Resources Management
Experience/Expertise: Outdoor Recreation, Park Management, and Rural Tourism
Role in EIS Process: Recreation and Tourism Analysis

Karen Kelly, Programmer/Analyst (Anteon)—Bachelor of Music in Vocal Performance
20 years of experience
Experience/Expertise: Programming, GIS Analysis, Internet Preparation/ Maintenance/Coding, Technical Writing/Editing, Software Development and Configuration, Database Development, Graphics
Role in EIS Process: Feasibility Study Web Site Development and Management; Document Preparation, Coding, and Formatting for the District Web Site

Bridgett Read, Programmer/Analyst (Anteon)—B.A. Physics, B.A. Environmental Studies
3 years of experience
Experience/Expertise: Geographic Information Systems Analysis, Database Development/Design, Graphic Analysis/Design, and Spatial Data Conversion
Role in EIS Process: Graphic Assembly of Main Report GIS Plates and Snake River Maps Appendix

Robert Herres, Student Co-op—AAAS Civil Engineering Technology
5 years of experience
Experience/Expertise: CADD and GIS Applications
Role in EIS Process: Graphic Assembly for Snake River Maps Appendix and FR/EIS GIS Plates

George Hardin—A.A. Mechanical Design and Drafting
12 years of experience
Experience/Expertise: GIS, Data Conversion, and Data Research
Role in EIS Process: Snake River Maps Appendix

U.S. Army Corps of Engineers, North Pacific Division

Dennis Wagner, Plan Formulation and Economist—B.A. Economics
26 years of experience
Experience/Expertise: Planning, Economic, Policy Issues, and Economic Studies for Water Resource Projects; Economics, and Civil Works Policy Issues
Role in EIS Process: Chairman, Drawdown Regional Economic Workgroup

Joe Johnson, Hydraulic Engineer—B.S. Civil Engineering
20 years of experience
Experience/Expertise: Hydroelectric System Operation Studies
Role in EIS Process: Hydroregulations Appendix

David Ponganis, Civil Engineer—M.S. Civil Engineering
19 years of experience
Experience/Expertise: Water Resource Planning, Endangered Species Act Section 7 Consultation
Role in EIS Process: Review of Main Report, Assist in Preparing and Coordinating Biological Assessments, and Regional Coordination

Witt Anderson, Fishery Program Manager—M.S. Resource Management
22 years of experience
Experience/Expertise: Fishery Program and Project Management; Water Resources Planning Studies Management; Environmental Studies; NEPA Document Preparation
Role in EIS Process: Program Management, Regional Interface, Policy Review

Jim Fredericks, Economist—M.S. Applied Economics, B.S. Economics
11 years of experience
Experience/Expertise: Economics Evaluation of Civil Works Projects
Role in EIS Process: Assisted in the Study Management and Review of Economic Studies

U.S. Army Corps of Engineers, Portland District

Tim Kuhn, Regional Economist—M.A. Resource Economics, B.S. Resource Economics
12 years of experience
Experience/Expertise: Economic Evaluation of Water Resources Projects
Role in EIS Process: Water Supply Economic Analysis and Implementation Cost Analysis

Joe Hise, Regional Economics—M.A. Economics, B.S. Economics
27 years of experience
Experience/Expertise: Economics and Planning
Role in EIS Process: Transportation Analysis

Edwin Woodruff, Chief, Economics Section—B.A. Economics, B.A. Mathematics
26 years of experience
Experience/Expertise: Economics and Hydropower Analyst
Role in EIS Process: Hydropower Analysis and Economics Review

U.S. Environmental Protection Agency

Mary Lou Soscia, Columbia River Coordinator—M.A. Geography/Water Resources, B.A. Geography/Water Resources
22 years of experience
Role in EIS Process: Agency Representative for Water Quality

John Bregar, Regional Hydropower Coordinator—B.A. International Environmental Studies
6 years of experience
Role in EIS Process: Agency Representative for Water Quality and NEPA

Bill Ryan, Environmental Engineer
Role in EIS Process: Agency Representative for Air Quality

U.S. Bureau of Reclamation

Susan Black, Social Science Analyst—B.A. Economics
Experience/Expertise: Social Analysis and Public Involvement for NEPA Compliance
Role in EIS Process: Social Analysis

Robert Christensen, Regional Environmental Officer—M.S. Wildlife Science, B.S. Biology
26 years of experience
Role in EIS Process: Biological Analysis Reviewer

Allen Reiners, Agricultural Economist—M.S. Agricultural Economics, B.S. Agriculture
31 years of experience
Role in EIS Process: Economic Analysis

Richard Rigby, Program Manager, Water Rights and Acquisition—B.S. Economics
27 years of experience
Experience/Expertise: Water Contracting, Water Acquisition, and Water Rights
Role in EIS Process: Agency Impact Analysis

Richard Prange, Environmental Specialist—B.S. Natural Resources Management
29 years of experience
Experience/Expertise: ESA Section 7 Consultation, Water Project and Land Management Planning Activities
Role in EIS Process: Agency Representative

David Zimmer, Regional Water Quality Coordinator—Ph.D. Limnology, M.S. Limnology, B.S. Fish and Wildlife Biology
27 years of experience
Experience/Expertise: Water Quality and Limnology
Role in EIS Process: Water Quality Analysis

Bonneville Power Administration

Philip Thor, Mechanical Engineer—B.S. Mechanical Engineering
24 years of experience
Experience/Expertise: Operations and Power Systems Analysis, Hydroregulation Review and Alternative Identification and Analysis Review, Transmissions Impacts, River Operations, and System Costs
Role in EIS Process: Agency Coordinator, Hydropower Analysis, and Hydroregulation Appendix

Audrey Perino, Industry Economist—M.A. Economics
20 years of experience
Experience/Expertise: Economic Analysis of Power Systems
Role in EIS Process: Hydropower Analysis – Power System Impacts

Marvin Laudauer, Electrical Engineer—B.S. Electrical Engineering
23 years of experience
Experience/Expertise: BPA Transmission Business Line, Network Planning, Transmission Impacts of Breaching the Lower Snake and John Day Dams
Role in EIS Process: Hydropower Analysis – Transmission Impacts

Kyle Kohne, Electrical Engineer—B.S. Electrical Engineering
8 years of experience
Experience/Expertise: BPA Transmission Business Line, Network Planning, Transmission Impacts of Breaching the Lower Snake and John Day Dams
Role in EIS Process: Hydropower Analysis – Transmission Impacts

Roger Schiewe, Hydraulic Engineer—B.S. Civil Engineering (Hydraulics)
29 years of experience
Experience/Expertise: Operations and Power Systems Analysis, Hydroregulation Review and Alternative Identification and Analysis Review, Transmissions Impacts, River Operations, and System Costs
Role in EIS Process: Hydropower Analysis and Hydroregulation Appendix

Foster Wheeler Environmental Corporation

Kirby Gilbert, Environmental Program Manager—M.S. Resource Geography, B.S. Environmental Science
18 years of experience
Experience/Expertise: NEPA Analysis, Environmental Policy and Compliance, Water and Natural Resource Allocation Studies
Role in EIS Process: Foster Wheeler Project Manager

Alan Olson, Fisheries Biologist—M.S. Fisheries Science, B.S. Aquatic Biology
10 years of experience
Experience/Expertise: Fish Biology; Pacific Salmon and Trout Habitat Requirements, Population Dynamics, and Behavior; Database Management
Role in EIS Process: Resident Fish Sections of FR/EIS

Brian Landau, Watershed Specialist—M.A. Geological Sciences, B.S. Geological Engineering
5 years of experience
Experience/Expertise: Hydrology, Water Quality, and Fish Habitat Data; Riparian and Stream Habitat Mapping; Geologic Mapping, Slope Stability Surveys, Surface-Groundwater Hydrologic Modeling
Role in EIS Process: Authored Geology and Soils Sections and Water Quality Sections of FR/EIS

Tom Martin, Consulting Engineer—B.S. Civil Engineering, C.A.S. Electronics
18 years of experience
Experience/Expertise: Water Resources, Civil Engineering, Software Development, GIS/CADD
Role in EIS Process: Water Quality and Hydrology Sections

Don Beyer, Fisheries Biologist—Ph.D. Fisheries Science, B.S. Fisheries Science
28 years of experience
Experience/Expertise: Interdisciplinary Watershed Analysis and Planning, Salmon Biology, Biological Evaluation of River Systems Operation
Role in EIS Process: Fisheries and Sections 2 and 3 of the FR/EIS

John Knutzen, Fisheries Biologist—M.S. Fisheries, B.A. Biology
22 years of experience
Experience/Expertise: Evaluation of Development Project Effects, including Hydroelectric, Forestry, Urban Land Development, and Mining on Aquatic Resources, Primarily Salmon and Trout
Role in EIS Process: Author of Anadromous Fish Section of FR/EIS

Gray Rand, Wildlife Biologist—Post-baccalaureate Studies, B.S. Biology
8 years of experience
Experience/Expertise: Terrestrial Mammal, Amphibian, and Bird Habitat, Ecology, Distribution and Demography Studies. Rare, Threatened, and Endangered Species Habitat Evaluation Procedures
Role in EIS Process: Wildlife Section of the FR/EIS

Bill Kerschke, Botany, Vegetation—Post-baccalaureate Studies, B.S. Biology and Wildlife Management
9 years of experience
Experience/Expertise: Habitat and Sensitive Plant Inventories, Wetlands, Riparian Areas, and Wildlife
Role in EIS Process: Vegetation Section of the FR/EIS

Matt Dadswell, Planner/Economist—Ph.D. Candidate Geography, M.A. Geography, B.A. Economics and Geography
9 years of experience
Experience/Expertise: Economics, Resource Allocation, Demand Studies, Social Analysis and Environmental Policy
Role in EIS Process: Economic and Social Sections of FR/EIS, Economics Appendix

Erik Nielsen, National Resources Policy Analyst—Ph.D. Candidate, M.A. Public Policy
5 years of experience
Experience/Expertise: Environmental Policy and Natural Resource Management
Role in EIS Process: Social Analysis

Mark Greenig, AICP, ASLA Landscape Architect/Recreation Planner—MUP Urban Planning, BSLA Landscape Architecture
19 years of experience
Experience/Expertise: Recreation Planning/Aesthetics/Land Use Planning
Role in EIS Process: Recreation and Aesthetics Section of the FR/EIS

Marcy Rand, Technical Writer/Editor and/Public Involvement Specialist—B.A. Journalism and Mass Communications
10 years of experience
Experience/Expertise: Technical Editing and Writing, Development and Publication of Public Involvement Materials
Role in EIS Process: Lead Editor for FR/EIS and Associated Documents, Public Involvement Program, Public Involvement Materials

Elesa Field, Technical Editor—B.A. English
7 years of experience
Experience/Expertise: Technical Writing and Editing, NEPA Document Coordination and Production
Role in EIS Process: Lead Editor for Draft FR/EIS

Lindsey Amtmann, Technical Editor—M.S. Environmental Psychology and Communications, B.A. Theater and Anthropology
7 years of experience
Experience/Expertise: Forestry and Hydropower Studies
Role in EIS Process: Lead Editor of Appendices

Karen Cantillon, Senior Technical Writer—B.A. English Literature
24 years of experience
Experience/Expertise: Public Involvement, Writing, Marketing, Event Planning
Role in EIS Process: Technical Editor for Appendices

Clarice Keegan, Technical Writer—M.A. Philosophy
21 years of experience
Experience/Expertise: Writing, Editing, Desktop Publishing
Role in EIS Process: Technical Writer for Summary, Technical Editor for Appendices

Tim Richards, Marketing Art Director—2 years of college courses
21 years of experience
Experience/Expertise: Graphic Design and Art Direction
Role in EIS Process: Design and Art Direction on Summary Document, Graphic Design for FR/EIS and Appendices

Don Bergquist, Word Processor—Certified with Microsoft Software
6 years of experience
Experience/Expertise: Word Processing Document and Table Preparation, Scanning and Placement of Graphics
Role in EIS Process: Lead Word Processor for FR/EIS

Steve Flegel, Word Processor—A.A.S. Printing
12 years of experience
Experience/Expertise: Desktop Publishing, Web Design, Various PC and Macintosh Applications
Role in EIS Process: Lead Word Processor for Appendices

Other Contributors to the Study Process

National Marine Fisheries Service

Dr. Steve Freese
Lynne Krasnow
Tom Cooney
Dr. Peter Karieva
Michelle McClure

U.S. Fish and Wildlife Service

Don Haley
Marv Yosinaka
Pat Bigelow

Northwest Power Planning Council

Terry Morlan

Parametrix

Dr. John Toll

Decision Support

Walt Haerer

Agricultural Enterprises

Dr. John Loomis

Bill Spencer

John McKean

Consultants

Hans Radtke

Tom White

Linda Wear

The Research Group

Shannon Davis

Belyea, Sorenson, Trottier and Associates

Paul Sorenson

University of Idaho

Dr. Chuck Harris

Dennis Becker

Dr. William McLaughlin

Dr. John Ratti

Dr. Kirk Lohmann

Dr. Ronald Robberecht

Anne Rockledge

Susan Loper

Triangle Associates, Inc.

Dennis Clarke

Project Time and Cost, Inc.

Kate Larson

Diana Bebee

Upper Great Plains Transportation Institute

Gene Griffin

Kim Vaschal

Marshall University

Mark Burton

Institute for Water Resources

David Grier

Sverdrup

Rolf Wielick
Peter Christiansen

ENSR

Chick Sweeney
Perry Johnson

Blair, Inc.

Bruce McPherson

Odyssey Productions, Inc.

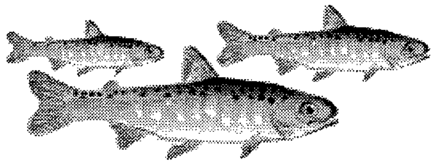
Steve Heiser
Carolyn Zelle
Donna Matrazzo

Normandeau and Associates

Terry Easton
Marcia Bowen

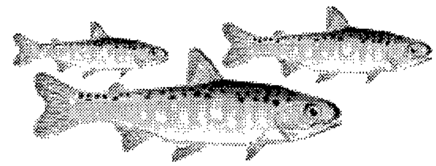
Battelle, Pacific Northwest National Laboratory

Tim P. Hanrahan
Marshall C. Richmond



Chapter 13

Distribution List



13. Distribution List

AGENCIES

Alaska Department of Fish and Wildlife

Advisory Council on Historic Preservation

Bonneville Power Administration

Bureau of Land Management

Bureau of Reclamation

Centers For Disease Control

Clearwater RC&D Area, NRCS

Community of Aspen Springs

Department of Commerce, NOAA

Department of Community Development

Department of Energy

Department of Natural Resources

Department of the Interior

Division of Environmental Quality

Division of State Lands

Environment & Natural Resources

Environmental Protection Agency

Federal Energy Regulatory Commission

Federal Highway Administration

Heppner Ranger District

Idaho Department of Agriculture

Idaho Department of Environmental Quality

Idaho Department of Fish and Game

Idaho Department of Health and Welfare

Idaho Department of Parks and Recreation

Idaho Department of Water Resources

Idaho State Historic Preservation Office

Idaho State Water Board

Idaho Water Resources Research Institute

Interagency Committee for Outdoor Recreation

Interior Columbia Basin Ecosystem Management Project

Joint Legislative Audit and Review Committee

Library of Congress

Methow Valley Ranger District

Montana Dept of Fish, Wildlife, & Parks

Montana Dept of Natural Resources

National Marine Fisheries Service

National Park Service

Natural Resource Conservation Service

Northwest Fisheries Science Center

Northwest Power Planning Council

Oregon Department of Fish & Wildlife

Oregon Department of Transportation

Oregon Division of State Lands

Oregon Economic Development Department

Oregon Emergency Services Division

Oregon Farm Bureau

Oregon Natural Resources Council

Oregon State Marine Board

Oregon State Police

Oregon State University

Oregon Water Resources Congress

Oregon Water Resources Department

Pacific States Marine Fisheries Commission

Senate Democratic Caucas

Special Districts Association of Oregon

State of Idaho

State of Wyoming

U. S. Bureau of Reclamation

U.S. Army Corps of Engineers

U.S. Army Institute for Water Resources

U.S. Bureau of Indian Affairs
U.S. Bureau of Reclamation

U.S. Coast Guard

U.S. Department of Agriculture

U.S. Department of Energy

U.S. Department of Justice

U.S. Department of the Interior

U.S. Fish and Wildlife Service

U.S. Forest Service

U.S. Geological Survey

Umatilla County Soil & Water Conservation

Umatilla National Wildlife Refuge

USDA – Farm Service Agency

Washington Department of Health

Washington Department of Transportation

Washington Agriculture and Rural Development

Washington Department of Agriculture

Washington Department of Ecology

Washington Department of Fish and Wildlife

Washington Department of Natural Resources

Washington Department of Transportation

Washington Energy Division

Washington Energy Facility Site Evaluation Council

Washington Parks and Recreation Commission

Washington Water Resources

Wyoming Game and Fish Department

INSTITUTIONS

Boise State University

Colorado State University

Dartmouth College

Gonzaga University

Highlands Middle School

John F. Kennedy School of Government, Harvard University

Kennewick School District

Lewis and Clark State College

Northwestern School of Law

St. Vincent College

University of California, Davis

University of Idaho

University of Oregon

University of Washington

Washington State University

Washtucna High School

Weston-McEwen High School

Whitman College

ELECTED OFFICIALS— FEDERAL AND STATE

Honorable Max Baucus, United States Senate

Honorable Conrad Burns, United States Senate

Honorable Chuck Carpenter, Oregon House of Representatives

Honorable Gary Chandler, Washington House of Representatives

Honorable Helen Chenoweth, U.S. House of Representatives

Honorable Larry Craig, United States Senate

Honorable Mike Crapo, United States Senate

Honorable Barbara Cubin, U.S. House of Representatives

Honorable Jerome Delvin, Washington House of Representatives

Honorable Jennifer Dunn, U.S. House of Representatives

Honorable Eve Franklin, Montana State Senate

Honorable Jim Geringer, Governor of Wyoming

Honorable Slade Gorton, United States Senate

Honorable Bill Grant, Washington House of Representatives

Honorable Shirley Hankins, Washington House of Representatives

Honorable Richard (Doc) Hastings, U.S. House of Representatives

Honorable Rick Hill, U.S. House of Representatives

Honorable Cecil Ingram, Idaho State Senate

Honorable Grant Ipsen, Idaho State Senate

Honorable Douglas Jones, Idaho House of Representatives

Honorable June Judd, Idaho House of Representatives

Honorable Dirk Kempthorne, Governor of Idaho

Honorable John Kitzhaber, Governor of Oregon

Honorable Patricia Lantz, Washington House of Representatives

Honorable John Lim, Oregon State Senate

Honorable Gary Locke, Governor of Washington

Honorable Valoria H. Loveland, Washington State Senate

Honorable Lynn Lundquist, Oregon House of Representatives

Honorable Dan Mader, Idaho State Representative

Honorable Dave Mastin, Washington House of Representatives

Honorable Jim McDermott, U.S. House of Representatives

Honorable Marguerite McLaughlin Idaho State Senate

Honorable Cathy McMorris, Washington House of Representatives

Honorable Thomas Mielke, Washington House of Representatives

Honorable Bob Morton

Honorable Joyce Mulliken, Washington House of Representatives

Honorable Patty Murray, United States Senate

Honorable David Nelson, Oregon State Senate

Honorable George Nethercutt, U.S. House of Representatives

Honorable Laird Noh, Idaho State Senate

Honorable Val Ogden,
Washington House of
Representatives

Honorable Horace
Pomeroy,
Idaho House of
Representatives

Honorable John Porter

Honorable Marc Racicot,
Governor of Montana

Honorable Carol
Richmond,
House of Representatives

Honorable Mark
Schoesler,
Washington House of
Representatives

Honorable Larry Sheahan,
Washington House of
Representatives

Mr. John Sisk,
Office of the Governor of
Alaska

Honorable Gordon Smith,
United States Senator

Honorable Sid Snyder,
Washington State Senate

Honorable Ruby Stone,
Idaho House of
Representatives

Honorable Charles
Swysgood,
Montana State Senate

Honorable Craig Thomas,
United States Senator

Honorable James
Tuschhoff

Honorable Moon Wheeler,
Idaho State Senate

Honorable Ron Wyden,
United States Senator

TRIBES AND TRIBAL ORGANIZATIONS

Burns Paiute Tribe of the
Burns Paiute Indian
Colony

Coeur D'Alene Tribe of
Idaho

Columbia River Inter
Tribal Fish Commission

Confederated Salish and
Kootenai Tribes of the
Flathead Reservation,
Montana

Confederated Tribes and
Bands of the Yakama
Nation of the Yakama
Reservation

Confederated Tribes of the
Colville Indian
Reservation

Confederated Tribes of the
Umatilla Indian
Reservation

Confederated Tribe of the
Warm Springs
Reservation of Oregon

Kalispel Indian
Community of the
Kalispel Reservation

Kootenai Tribe of Idaho

Nez Perce Tribe

Northwestern Band of the
Shoshoni Nation

Shoshone-Bannock Tribes
of the Fort Hall
Reservation

Shoshone-Paiute Tribes of
the Duck Valley
Reservation

The Spokane Tribe of the
Spokane Reservation,
Washington

Wanapum Band

LOCAL GOVERNMENT

Asotin Chamber of
Commerce

Asotin County

Bellevue Chamber of
Commerce

Benton County Board of
Directors

Benton-Franklin Council
of Governments

Benton-Franklin Regional
Council

Boundary County Board
of Commissioners

Clearwater County
Commissioners

City of Boardman

City of Burley

City of Clarkston

City of Dayton

City of Irrigon

City of Kennewick

City of Lewiston

City of Orofino

City of Pasco

City of Peck

City of Pendleton

City of Pomeroy

City of Richland

City of The Dalles

City of Umatilla

City of Waitsburg

City of West Richland

City of Boardman

City of Stevenson

Clarkston Chamber of Commerce

Clearwater County Board of Commissioners

Columbia County Commissioners

Deer Park Chamber of Commerce

Franklin County Commissioners

Garfield County Commissioners

Greater Pasco Area Chamber of Commerce

Idaho-Oregon Planning & Development

Lewis County Board of County Commissioners

Nez Perce County Commissioners

Orofino Chamber of Commerce

Pasco Chamber of Commerce

Richland Chamber of Commerce

Spokane Area Chamber of Commerce

Tri-Cities Visitor Convention Bureau

Tri-City Area Chamber

Walla Walla County Commissioners

Wallowa County Commissioners

Whitman County Commissioners

ORGANIZATIONS

3B's Moving & Storage

A & M Farms, Inc.

A-1 Body Shop

AEI Enterprises, Inc.

Agri-Northwest

Agri-Times Northwest

Alaska Troller Association

ALM Farming, Inc.

Almota Elevator Company

American Fisheries Society

American Rivers

American Waterways Operators

American West Steamboat Co.

AmeriCorps/NWSA

Association of Idaho Cities

Association of Northwest Steelheaders

Ater, Wynne, Hewitt, Dodson, et al.

Atlas Sand and Rock

Audubon

Automatic Flagman County Airport

Badger Mountain Irrigation District

Badger Mountain Irrigation District

Bar Star, Inc.

Batelle Pacific Northwest Laboratories

BC Hydro and Power Authority

BC Utilities Commission

Bear Creek Farms

Benton County PUD

Berg Brothers Farm

Bernert Barge Lines

Big Bend Economic Dev. Council

Big Bend Electric Coop, Inc.

BioAnalysts, Inc.

Blue Dog Ranch

Blue Mountain Audubon Society

Blue Mountain Publishing, Inc.

Blue Mountain Valley Physical Therapy Clinic

Blue Oval Co.

BNP Lentil Company

Boise Cascade Paper Division

Boise-Kuna Irrigation District

Boise-Kuna Irrigation District

Bonneville County Sportsmen

Braden Rural Electric Association

Brown's Eden Tree Farm

BST Consultants

Bullivant Houser Bailey Pendergrass & Hoffman

Burbank Homeowners

Bureau of National Affairs

Canyon Property Owners

Cargill, Grain Division

Cascade Columbia Foods

Cascadians

Cegnar, Inc.

Central Basin Audubon Society

Central Ferry Terminal Association

CH2M Hill

Chelan County PUD

Cherrylane Ranches, Inc.

Citizens for Better Health

Clark County Pomona Grange

Clarkston Estates

Clarkston Golf and Country Club

Clearwater Flycasters

Clearwater Management Council

Clearwater Power Company

Clover Island Yacht Club

Coalition for Anadromous Salmon and Steelhead Habitat

Columbia Basin Fish and Wildlife Authority

Columbia Basin Fly Casters

Columbia County Grain Growers

Columbia Grain International, Inc.

Columbia River Alliance

Columbia River Estuary Study Taskforce

Columbia River Fishermen's Protective Union

Columbia Rural Electric Association

Columbia Rural Electric Association

Columbia Valley Grange

Committee of 9

Common Sensing, Inc.

Continental Grain Company

Cottonwood Fiber Farm

CRFPU

DeAtley Co. Inc.

Deep Sea Charters

DES Research

Diamond H Construction

Direct Service Industries, Inc.

Dix Corporation

Douglas County PUD

Dworshak Excursions

East Columbia Basin Irrigation District

Ecumenical Ministries of Oregon

EF Engineering

Elmer's Irrigation

Emerald Farms

Emerson Logging

Empire Lumber Company

Energy and Natural Resources

ERO Resources

ESD #123

F Bar C Ranch

Far West Fertilizer & Agrichemical Assoc.

Farm Bureau

Farm Credit Services

Federation of Fly Fishers

Fish Passage Incorporated

Foss Maritime Company

Foster-Wheeler Environmental

Franklin County PUD

Fuller Consulting Services

Future Farmers of America

Geologic Analysis & Consulting Svcs

Givens, Pursley, & Huntley

Goffinet Farms

Golder Associates, Inc.

Granger Company

Grant County PUD

Gray Hut Apartments

Guard Strang Edwards Aldridge

Guy Bennett Lumber Company

Hargis Engineers, Inc.

Harper Chiropractic Pain Relief Clinic

HARZA Northwest

Hawley, Troxell, Ennis & Hawley

HDR Engineering

Hells Canyon Alliance

Howard Brothers

Huckell Weinman Associates

Hydro Review Magazine

I.G.P.A.

Idaho Barley Commission

Idaho Cattleman's Association

Idaho Council on Industry & the Environment

Idaho Environmental Council

Idaho Farm Bureau Fed.

Idaho Grain Producers Association

Idaho Power Company

Idaho Power Council

Idaho Rivers United

Idaho State Grange

Idaho Water Alliance

Idaho Water Users Association

Idaho Wheat Commission

Idaho Wildlife Federation

Idaho Women in Agriculture

INCA Engineers

Inland Empire Fly Fishing Club

Inland Empire Jetdock

Inland Empire Public Lands Council

Interior Design Associates

International Water Power and Dam Construction

Ironworkers #14

IRZ Consulting

J-Bar S, Inc.

JF Micro

Jones & Stokes Assoc.

Jones and Jones

JSA Farms, Inc.

K & J Enterprise

K&N Industrial Equipment

Kaiser Aluminum

Kaotenai Environmental Alliance

Kauerrer Brothers

Kelly Creek Flycasters

Kennewick Irrigation District

Kimball Engineering

KONA Radio

Kuther Ranch

L&M Farms

Laib Brothers

Lamb-Weston

Lamont Grain Growers, Inc.

Lazy H-K Ranch

Legrow Water Co.

LePage Farms

Lewis-Clark Economic Development Association

Lewis-Clark Wildlife Club

Liebler, Ivey, & Connor

Lillard's RV Park

Littler Farm, Inc.

Lockheed Martin Idaho Technologies Company

Logistics International

Louis Dreyfus Corporation

Lower Columbia Basin Audubon Society

Lower Columbia Fish Enhancement Group

Lower Columbia River Estuary Program

Lyons Ferry Marina

Maxim Technologies

McCormack Land Design

McGregory Company

McNary Farm

Means Building Co.

Mercer Ranch

Metz Marina, Inc.

Mid Columbia Producers

Middle Snake Regional Water Resource Comm.

Middleton Six Son Farms

Ministry of Environment

Morbeck and Beeler Inc PS Law Office

Morken Ranch

Motyka's Fishin Post

National Wildlife Federation

Native Fish Society

Neace Farms

Neil F Lampson

New Pioneer Log Homes, Inc.

News Data Corporation

Newsdata Corporation

Niemi, Holland & Scott

Norm Druffel & Sons

Normandeau Associates

North End Grange #820

North Side Canal Company

Northwest Economic Research, Inc.

Northwest Environ Watch

Northwest Power Planning Council

Northwest River Runners

NSIA

NW Council of Governments

NW Resource Information Center, Inc.

NWCOGA

NWSSC

Oak Ridge National Lab

Oakesdale Farm

Oregon Trout

Oregon Water Coalition

Oregon Wheat Growers League

Pacific Fishery Management Council

Pacific Northwest Project

Pacific Northwest Waterways Association

Pacific NW Grain & Feed Assoc.

Palouse Grange

Palouse RTPO

Phil's Sporting Goods, Inc.

Pomeroy Grain Growers, Inc.

Port of Benton

Port of Clarkston

Port of Kennewick

Port of Lewiston

Port of Morrow

Port of Pasco

Port of Portland

Port of Umatilla

Port of Walla Walla

Port of Whitman County

Portland Bureau of Environmental Services

Potlatch Corporation

Prior West Farms

Propps Rod and Fly

Public Power Council

Public Utility District No. 1 of Asotin County

Pulp & Paperworks Resource Co.

Pulp and Paperworkers Resource Council

Quincy-Columbia Basin Irrigation District

R & R Plan-Soil Inc.

R.A. Hanson Co.

Rattlesnake Ranches, Inc.

Raymar Inc.

Reese, Baffney, Schrag & Frol

Resource Writers Northwest

Richland Rod and Gun Club

Ritzville Warehouse Co.

River Network

River View Estates

Riverside Water and Sewer District

Riverview Marina

Roach Law Offices

Robert K. Bauer & Associates

Roshoh, Robertson, and Tucker

Roza Irrigation District

S & S Farms

Safe Casters

Sage Hill Northwest

Salmon Corps

Salmon for All

Save our Wild Salmon

Schlueter Ranch's, Inc.

SCM Consultants

Seattle City Light

Seattle City Light

Seattle Times

Settlers Irrigation District

SFCC Life Sciences Dept.

Shaver Transportation

Short Cressman & Burgess P.L.L.C.

Sierra Club

Sky Runner's Corp

Snake River Preservation Council

Snohomish County PUD

Snyder Law Offices

South Columbia Basin Irrigation District

Southern and Sons

Stahl Hutterian Inc.

Stanfield Westland Irrigation District

Startin, Inc.

Stoel, Rives, LLP

Sunheaven Farms

T & R Farms, Inc.

Tenaska

The Grime Fighters

The Lands Council

The Montana Outdoor Radio Show

Tidewater Barge Lines, Inc.

Tidewater Terminal

Timberworkers Resource Council

Tippett Land & Mortgage

Touchet Valley Graphic

Touchet Valley Irrigation District, #16

TREC

Tremblay Associates, LLC

Tri-Cities Visitor Convention Bureau

Trout Unlimited

Trout Unlimited-Idaho

Troutman Sanders LLP

UAP Northwest

Umatilla Electric Coop Association

Umatilla Electric Cooperative

Union Elevator

Uniontown Coop Association

Unit 309

United Power Trades Org.

Unocal

Unocal Agriculture Products

Upper Snake River Fly Fishers, Ltd.

Valley Boat and Motor

Valley Car Sales and Rental

Valmont NW

Vancouver Water Resources Education Center

Vandenburg Sales, Inc.

Vilcor Farms

Walla Walla Conservation District

Walla Walla Grain Growers

Warm Springs Agency

Washington and Idaho Wildlife Federations

Washington Association of Wheat Growers

Washington Cattlemen's Association

Washington Grower's League

Washington State Grange

Washington State Parks & Recreation Commission

Washington State Potato Commission

Washington Water Power Company

Washington Wheat Commission

Washington Wildlife Federation

Washington Wool Grower's Association

Water Development Commission

Water District Number 65

Water Research Center

Waterfront Products, Inc.

Weather or Not Inc.

Wenatchee World

West Rock Inc.

Western Construction & Logging

Western Montana Electric G & T Cooperative, Inc.

Western Outdoors

Westland Irrigation District

Whetstone Farms

Whitman County - BOCC

Whitman County Association of Wheat Growers

Whitman County Parks

Whitman County Public Works

Wilbur-Ellis Company

Wild River Ranch

Wildlife Forever, Inc.

Wood Dental Lab

Worden Farms

WSU Extension Watershed Steward

Yakama Agency

LIBRARIES

Asotin County Library

Boise Public Library

Boley Library

Colorado State University Libraries

Columbia Basin College Library

Government Publications

Idaho State Library

Lewiston City Library

Oregon State Library
Oregon Trail Library District

Preston Public Library

Richland Public Library

Salem Public Library

Seattle Public Library

Spokane Public Library

Tri-Community Library

U.S. Geological Survey Library

University of Oregon Library

Walla Walla College Library

Walla Walla Public Library

Wenatchee Public Library

White Salmon Community Library

Woodland Public Library

MEDIA

Capital Press

Capital Press Newspaper

Dayton Chronicle

Hermiston Herald

Pacific Northwest Inlander

The Daily News

The Oregonian

The Spokesman Review

The Tri-City Herald

Tri-City Herald
Valley Times

Walla Walla Union Bulletin

INDIVIDUALS

Jeff Abrams
Robert Adams
Tim Adams
Jason Adler
Dwight W. Afflecu
Chris Akerblade
Chris Akerblade
Jamie Albert
Lee Alexander
Ken Alford
Tom Alkire
Jimmie Allen
Perry Allen
Bessie Allen
Edwina Allen
Bruce Allen
Clint Allen
Howard Alligier
Loren Amack
Harry C. Ames
Julie Ammann
Alfred Amoureux
Pamela D. Anderson
Norman Anderson
Don Anderson
Norm Anderson
Brad Anderson
Nathan Anderson
Eugene Andrews
Robert Andrews
Steve Anglea
Douglas Ankrom
Manford E. Anliker, PT
Loretta Antell
F. Curtis & Shirley Archer
Brian Arend
Mike Arland
Don Armstrong
Andrew J. Arvish
Gail Aten
John Atkins
Lanis N. Aultz
Roger Bagley
Pat Bailey
Irvin Bailey
Carolyn Baird
Ray Baker
Susan Baker
Bob Baker
Daniel A. Bales
L.L. Bales
Del Ballard
Alex Barkume
Carol Barnard
Lane Barney
Donnie Barr
Ronald G. Barrett
Bettie Baser
Mike Bateman
Lee Bauer
Ronald Bauer
Dale Bauermeinter
Robert A. Bauman
James J. Bauman
Randy Bayer
Brandon Beatz
Dale Becker
Dennis Becker
Bob Becker
Virgil E. Beckner
Helen K. Beckner
Paul Beddoe
John Bellinger
Albert Bendle
Frank Benish
Brian Bennett
Emily A. Bennett
David Bennion
Bill Benson
John E. Bentley
Jennifer Bereronce
Ronald Berg
Matt Berg
James Berg
Jerry Berg Sr
David Bergeron
Margaret Bergevin
Kassen Bergstrom
Steve Bernert
Kathryn Berry
Jim Berry
B. Rodney Bertramson
Donna K. Beutler
Dan Bickelhaupt
Tennys Bickelhaupt
John Bickford
Michael Bickford
Wallace Biederstedt
Clarence E Binninger
Jon Binninger
Jack E. Bird
Larry Birdwell
Larry Bishop
Barbara Bisset
Tyrie Bivings
Mick Blackburn
Steve Blair
Troy Blake
Patrick Blank
Delmer Blankenship
John T. Blankenship
Frederic Blauert
Lynn Bleazard
Gary Blevins
Jack Blewett
David Blomberg
D. W. Blumhagen
Paul Boeckman
Douglas Boggan
Dave Bohlman
Kenneth Boire
Floyd Bolich
Randall Bond
Rodney Bonifer
Wendy Bonnali
Jake Bonner
James C. Bonner
Mark Booker
Dan Boone
Mark Bordsen
Rick Bostrom
Jerry Bouck
David N. Bowen
Robert V. Bowersock

Tony Bowler
Larry Bowles
Thomas Bowman
Jerry Boyd
John Bradbury
Tony Bradbury
Richard Bradbury Jr.
Walter Bradeho
James Bradford
Beverly Bridgewater
Jessica Briggs
Scott Brim
George Brocke
Robert Brodahl
Chris Bromley
Raymond Brooks
Craig Brougher
Harry Brounle
Carol J. Brown
Don D. Brown
Helen Brown
Mike Browne
John S. Broz
David Brubaker
T. K. Bruce
T.J. Bruce
Steve Bruce
Andy Brunelle
Douglas G. Bube
Larry Buchanan
Craig Buchanan
Norman Buckholz
Marie Buckley
David M. Bull
Viola Bulteno
Gordon G. Bundy
Dan Buob
Brian A. Burford
Marilyn Burg
Bill Burgel
Patricia Burke
Reed Burkholder
Scott Burnm
John Burns
Lucian Burns
William C. Burns
Willetta Burns
Doug Burr
Dee J. Burrie
Gordon & Barbara Burt
Tom C. Busch
Karen Caddey
Jim Caddey
Josh Calhun
Lynn Call
Ken Calvert
Lyle Calvin
Benella Caminiti
Steve Camp
Stella Canfield
Ron Canoy
Hawey Capsey
Zane Carey
Terry B. Carlson
Rich Carlson
Charles Carlson
David W. Carlton
Lynn & Sharon Carol
Bryan Carpenter
Matt Carroll
Chuck Carruthers
Larry J. Carson
Colette Casey
E. Cassens
Arnoldo Castillo
Phil Cathey
Wade Cavender
Lorraine Cavener
Esther Ceja
Jack Chadwell
Robert Chandler
Don W. Chapman
Lois Charbonneau
Cecil Charles
Don Chatfield
W.E. Chetwood
Joseph Chiantaretto
George Chicha
Tom Chikalla
Howard Christen
John Christensen
Barry Christensen
K. Christensen
John E. Christenson
Ted Chu
Dan Claassen
William G. Clark
Shirley K. Clark
Dale Clark
Jack B. Clarke
Wayne Clary
Susan Clausen
Marv Clement
John Clements
Francoise Cleveland
Charles M. Clifford
Norman Close
Phil Clouse
Clyde Cochlin
Robert Cochran
Harold Cochran
LeRoy Cocking
Cal C. Coie
Brad Cole
David Cole
Rodger Colgan
Donald G. Collier
Michael Collins
Harold Colton
Joseph Daniel Conalt
John Conant
GE Conatore
Lonnie A. Conner
Adele Connors
Lloyd Cook
Sunny Cook
Everett Cook
Walter Cook
Catherine Cook
Dick Coon, Sr.
Nicole Cordan
H.D. Coret
E. Cornell
Jack Correa
D. Cosgrove
Larry Couch
Clifford Courtney
John Covert
Frederick K. Cramer
G.D. Cran
David Crane
C. Clare Cranston
Robert Crater
Dennis Crater
Bill Criddle
Deb Cridlebaugh
Wayne Crosby
Marietta Cross
John Crouse
Bob Crump
Gary Culbert
Dorothy Cullen
Harry Cummings
Thomas Curet
Sylvester Czmowski
Jeff Dagle
Mary Dallolio
Jim Daniels
Dave & Kathy Daniels
Sean Darcy
Don Darter
Michael L. Davidson
Ailene A. Davis
Seth Davis
Gerald Davis
Chase Davis
Beryl Dawkins
Jack & Murriel Dawson

Janet M. De La Rosa
Bart Dearborn
Jim Deatherage
Diane DeFelice
Nancy DeLoranzo
Jerome DeLuin
Francis Denevan
Robert W. Dennler
George F. Dennler
George Denny
Raymond DeRuwe
Carl R. Dettwiler
A Devoe
Ken DeWeber
Harry DeWitt
Mary Lou Deyo
Sherry Dice
Robert G. Dick
Wayne Dickhaut
Dean Dickinson
Jeffery Dill
Ray Dillard
Ross Dimmick
Clyde Dimmick
Chris Dingle
Jim DiPeso
Don Dixon
Les Doering
Evelyn Dolling
Charlotte Domenico
Floyd Domini
Doug Donner
Ryan W. Donohue
Heidi Dornier
George Dorsey
Chris Doyle
Robert Drake
Vern Driver
John Droddy
Donald G. Druffel
Robert F. Druffel
Don Dryson
Dick Dudley
Ken Duffield
Bryan DuFosse
Robert D. Dunnagan
David Duvall
John R. Dyer
Alfred Dymond
Leroy Eadie
Joe Eagan
Richard L. Earnheart
Glen H. Eaton
Boyd Eberhardt
Gene Eberts
Frederick Eby
Mark Edelblute
Harry M. Eder
Michael Edmonson
James Edton
Marie Edwards
Dan Egan
Leon Eggers
Doug & Marie Eier
Anna Marie Eier
Cub K. Eikes
Steve T. Emmett
Jack Ensley
Marvin Entz
Michael W. Erho, Jr.
Josh Erickson
Roland Erikson
Harry C. Erno
Scott Erwin
Ralph Eshleman
Barry Espenson
Gene Esser
Robert Estuar
Matt Etchamendy
Larry Etter
Billy B. Evans
Russ Evans
George C. Evans
Dennis Evans
Hugh O Evans
Ken Everf
Alvin Everts
Joffre Ewing
Ira J. Fackenthall
Thomas Faerber
Frances R. Faughn
Ed Faus
Lee Feigam
Roy Feiguson
Katherine Felice
Truman Fergin
Larry Ferguson
Dick Fiddler
Ron Filkowski
Rich Fink
Ann Finley
Adam Fish
Allyn Fisher
John W. Fisher
Jack Fisher
Elwin L. Fisk
Charles Fisk
Buck Fitch
James Fitzgerald
Rebecca Fitzgerald
Mel Fitzpatrick
Wayne Fitzsimmons
Jack J. Fix
Michael Flanagan
Benjamin Flathers
Jessie Fletcher
Cathy Flint
Roberto Flores
Lupito Flores
Stewart Floyd
Verna Foley
Pat Ford
Andy Ford
Ivan W. Foster
Jack Fouts
Lawton Fox
Diana Fraemka
Daryl Francis
Juddie V. Franklin
Forest Franklin
Bobbie Frazier
Richard Fredericks
Lola Fredrick
Helen Fredrick
Newell Freeman
Catherine Freeman
Louise Freeman-Tork
Charles R. French
Lynn Fritchman
Greg Frizzell
Edwina Furley
Duane Gage
Steve Galka
Scott Gallert
Jeremy Galles
Carl Gangl
Larry Gannon
Leo Garcilazc
Zach Gartz
George Gault
Krista Gavstad
Jill Gayheart
C. J. Geidl
Dallas A. Geidl
Richard Geis
Kim V. Geist
Alexander Gelles
Justin Gericke
Gene Gerkey
Glenda G. Germen
Stan Gerway
Shelly Gibb
Rex Gibbs
Thorvald Gilje
John Gilliam
Alfred E. Gilliam
Al Gilson
Lou Giovanini

James W. Givens
George Glaesmann
Les Godfrey
Chuck Goff
Rocky Goffinet
Stu Goldstein
Jerry Gordon
George Gorsline
Jim Gotts
Pamela Granger
Walter Gray
Robert H. Gray
Henry Greber
William E. Greeley
Joe Green
Art Green
Orval D. Green
Obie Green
Dianne Greenwald
Ron Greer
Guy Gregory
Clarence Gross
Ivl Grove
Luanna Grow
Gary & Sheila Guernsey
James E. Guier
David Gumm
Lester Gushe
Jack Guske
Jack Guske
Don Haas
Jim Haase
Kurt Hadaller
Tom Hadzor
Jim Hagar
Mark Hahn
Gary Hall
Jim Halliman
Robert W. Halsey
Greg Hamel
Joel Hamilton
Liz Hamilton
Linda Hammer
Robert L. Hammons, Jr.
Michael & Connie Hampton
J. Donald Handy
Reed Hanni
Nathaniel Hannon
Bruce Hansen
Lynn D. Hanson
Jim Harder
R.G. Harms
Jack L. Harney
Mike Harrison
Gary L. Hart
Michael Hart
Hal H. Hart
Sidney Harty
George Hashon
Mark Hausinger
Melinda Hawes
Ken Hawk
Vincent P. Hawkins
Bruce Hawkins
Phillip A. Hawman
James L. Hay
Ken Hayden
Ken Hayes
Thomas Hays
Harold Heacock
Patricia Heasler
Gary Heath
Larry Heidal
Gary Heidal
Douglas Heieren
Ernie Heimgarther
Donald Heinen
Jim Heitmann
H. Heitstuman
Robert G. Heitstuman
Phil W. Heitstuman
Dale A. Heitstuman
Edwin Helmstetter
Mark Hemingway
Wayne Hemmelman
Mark Hemphill
Marvin Henderson
Carl Hendrickson
Lynn Hendry
George Henriksen
Lloyd Henry
J.P. Herman
Don Hermann
Gus Hernandez
Ron Herndon
Matt Herres
Lisa Hetherman
Jack R. Heuett
Michael Heverson
Lewis H. Hewett
H. G. Hicks
Royce & Jean Hicks
Scott Highleyman
Alan Hille
Kurt Hillman
John Hinchliff
Jim H. Hinckley
Layne Hinckley
Al Hinkel
Jack Hockberger
Twila Hocnbeck
Ralph B. Hodge
James M. Hodges
Michael Hodges
Chris Hoffman
Porter Hogaboam
Vickie Hogen
Gene Hoilman
Barry C. Holben
Richard Hollenback
Janette Hollenback
Don Hollenbaugh
Jim Hollingsworth
Lavette Holman
David A. Holmberg
Jenny Holmes
Merle Hombake
Larry Honn
Bruce Honn
Bertie Honn
Lyle Honn
John R. Hood, Sr.
Joseph Horvath
Thomas Houchins
Jerome Hourud
Gerald Howard
Michael Howell
Frank Hoyt
Mike Hryekewicz
Gary Hubsmith
Arnold Hudlow
Richard Hudson
J. Lowell Huffman
Phil Hughes
Jack Hughes
Ross Hughes
Joan Hunter
Robert Huntley
Don Huntzinger
Daniel Huppert
Charles Huskey
Lawrence O. Hutchins
W. J. Ingram
Roy W. Isbelle
Jennifer Isenhart
Craig E. Iverson
Ken Jacks
Paul Jackson
Greg Jackson
M. Jackson
Don Jackson
Marvin Jacobsen
Doug Jacobson
Baruch Jacobson
Lynette Jagoda
Hollis L. Jamison
Jay Jasperson

Mike Jaspin
Bill A. Johns
Chester Johnson
Duane Johnson
Donald W. Johnson
Merle Johnson
Bruce Johnson
Duane Johnson
Gary Johnson
Don Johnston
Ronald Johnston
Barbara Johnston
Don Johnstone
Don Jones
Coralie J. Jones
Greg Jones
Ron Jones
Richard Jones
Ruth Jones
George Jones
Dick Jones
John A. Jones
Margie D. Jordan
Vernon Jorgensen
Phillip Jost
Claud Judd
Richard Juris
Frank Just
Steve Juul
Reed Kaldor
Loren Kambich
Kathy Kaser
Roy P. Kasper
Henry C. Kaufman
Jim Keating
Mike Kelly
Mike Kennedy
Steven Kennelly
Pat Kenny
Herbert Kent
Darrell C. Kerby
Elisabeth Kern
Kammy Kern-Korot
James C. Kerns
Bruce Kerr
Minott Kerr
David Kerrick
Barbara Kesel
Ronald F. Kessler
John J. Kestler
Chuck Ketterman
Lyle J. Kidder
Charles Kilbury
John Killinger
Rodney L. Kimble
Stewart Kime
Carl R. King
Stephen G. King
Ted Kinzer
Keith A. Kinzer
William J. Kinzer
Gary Kinzer
Raymond Klaudt
Linda Klein
Audrey Klein
Robert Kline
Bob Klingenstein
Lou Knesek
Tom Knight
Jon Knight
Randy Knight
Gary Knoche
El Knott
Telly Knutson
Anita Koehn
Andy Kohler
Derek J. Kolar
Terry Kolb
Roger W. Koller
Harvey Kom
Kevin W. Korbel
H. Kostandarithes
Tom Kovalicky
Dick Kremm
Donald J. Kriebel
Jim Kroenlein
Robert Kruger
Frank Krul
Kevin Kudik
Robert A. Kuther
David Kuzmer
Forrest Lacock
Eldon Ladd
Clif LaHue
Dennis Laib
Benjamin LaMacchia
Doug Lambert
Hazel Lande
Alvin Landrammer
Hubert Langenhurst
James C. Langford
Jim Langford
Jennifer Langston
Helen Langworthy
Mildred Lansing
Cecile LaPierre
Robert Larson
Lynn H. Laswell
Ramon Latham
Duane Lathim
Donald W. Lathrop
Darin Laughery
Suzanne Laverty
John Law
Nick C. Lawson
Eugene H. LeBaron
Robert Lee
Glenn Lee, Jr.
Bernt C. Lehn
Richard T. Lehn
Klaus Leidenfrost
Alvene Leinweber
Geo Lemmon
Bruce LePage
Cindi Lepper
James Lessly
Scot Levy
Yale Lewis
James Lewis
Ed Liddiard
Jim Lieuallen
Gilberta Lieuallen
Stephen J. Lindberg
Robert E. Lindsay
Lyle Lindsay
Shirley Lindstrom
Dave Linehan
Golden Linford
Nancy Lingle
Walter Littler
Mike Livingood
William C. Loft
Bill Loftus
George E. Lohse
Bob Lonn
Jesse Lott
Roy Lowary
Ted Lowe
James R. Lucas
Dorothy Luffman
Pete Luisa
Robert Luntey
Todd Lustmeister
Tracy Lybbert
Perk Lyda
Chris Lyle
Rex Lyle
Kevin Lyle
Greg Lynch
Roger Lyngaas
Arvid Lyons
Kim MacColl
H.M. MacDonald
Sam Mace
Ron Mackelprang
James Mackley
Tomas Madrigal
Harold E. Mahon

Mike Maller
Roy D. Mallory
Bill Mandell
Sandy Mansfield
Carl Mansperger
Carl Mantz
Brian Marquez
Nichole Marshall
Sam Marshall
Lyle Marshall
Patrick & Meta Marshall
Bob Martin
Dan Martin
Dave Marvin
Dean Mason
Ron Matheny
Michael Mathews
Mike Mathews
Theresa Mathis
Ernestine Mathot
James L. Matteson
Bob Mattilla
Colin Maxey
Hustin Mayberry
Lyle Maynard
Chris Mayor
Dale Mays
Kell McAboy
Jerry McBride
Bruce McCaw
Ron McClary
Jackie McClure
William McCormick
Oba McCoy
Jim McCurdy
Pat McDaniel
Robert McDonald
Robert McDowall
Bob McDowall
Herbert R. McDowell
Roy McDowell
Linda McFaddan
Randy McGarvey
Thomas McGrath
Thomas B. McGreeny
Betty McGregor
Dan McKenzie
George R. McKenzie
Doris McKillip
David McKinley
Cleo McKown
Robert J. McLaughlin
Ty Mclean
Patrick McNamee
Bill McSherry
Ruth A. Medlock
Travis Meinhold
Tyler Meinhold
Anna Melgaard
Ursula Melvin
Bud Mercer
Bob Meredith
John Merrik
Robert & Carol Meserve
Steve Meshishnek
Kenneth V. Meyer
Stan Meyer
Matt Meyer
Mildred Meyers
Shelly Mibbs
Phil Michel
F.H. Michel
Jeremy Michelson
Ted Mielick
Dan Mielke
Don Mikiska
Ray Miles
Neil D. Miller
Floyd Miller
Jennifer Miller
Larry Miller
Tom Miller
Virgil Miller
Clinton Miller
Jerry Miller
Daniel Miller
Harold Miller
Sue Miller
Jim Miller
Shannon Miller
Mark Millheim
Duane Minden
Mike Mineer
Robert Minter
Steve Mischke
Joseph Mitchell
David E. Mobley
Rebecca Modesitt
Tim Moe
William Moehrle
Gordon Moir
LeRoy Moldenhauer
Steve Money
Bud L. Monroe
Duane Moon
Lowell A. Moore
JoDean Moore
Victor and Roberta Moore
Tod L. Moore
Ann Moore
J. Moore
Randy Moore
George Morby
Edward Morefield
Howard Morgan
E. A. Morken
Terry Morlan
Howard Morris
Tom Morris
Don Morrison
Harvey Morrison
Ray Morscheck
Terri Morse
Frank Mull
Denis Munder
Wanda Munn
Annabell Munson
Phil Murdock
Ed Muzatko
John Nanninga
Larry Nass
Jim Neace
Warren Nechodom
Walter Neff
David Neff
Lindsay Nelson
Laura Nelson
Bill Newbry
Harry E. Newman
Cary Newman
Larry Newman
Lauren Newsome
John M. Newton
Ann Nibson
Clyde Nicely
William F. Niemela
Jon Nilsson
Fred Nolan
Charles R. Norris
Linda Norris
Charles Nowack
Carlos Nuarado
Ron Nugen
Carl Nyborg
Hollis E. Oakes
K. Oberst
Denise A. O'Bryan
Mike O'Bryant
Eva Ochoa
Dave O'Day
Neil H. Ofsthun
Hannah Ogden
Richard E. Ohms
Jasper Olinger
Darryll Olsen
Ralph Olsen
Whit Olsen
Wayne Olson

Jean A. Olson
Maynard Olson
Dale Olson
Robert L. Olson
Oliver W. Olson
Zach Olson
Rich Olson
Frank Opila
Rikki D. Osborn
John Osborn
Eugene A. Osterberg
Justin Ostheller
Rob Owings
Dennis Ownbey
Orlene Oylear
Lucian Pace
Lucian Pace
Sheila Pachernegg
Ernest Page
Eliseo Paniagua
Duke Parkening
Morley Paul
Dave Payne
Gwen Pearson
Ted Penner
Jay Penner
Sue Perin
Brian Perleberg
Darin Perna
Diane Perry
Lon Peters
W. J. Peters
Dana Petersen
Robert Petersen
James Petersen
Donald Petersen
Brenda Peterson
Keith Peterson
Mike Peterson
Arthur Peterson
Ken Peterson
Erik Peterson
James Pettit
Richard R. Phillips
Glenda J. Phillips
Larry Phillips
Kathleen Phillips
Norm Phillips
Joe Pickett
Arthur L. Pierce
Mark Pinch
Alex M. Pinkham
Rick Piper
Frank G. Pirnique
Donald Pittman
Tom Platt
John Plump
Duane Poe
R. Doug Poland
Dennis Poland
Dave Poncin
Patricia Pontefract
David Poor
Ed Porter
Steve Pottle
Barbara Poulson
Jim Powell
O. L. "Bud" Powers
Mike Price
Richard G. Price
Greg Prindiville
Terry Proctor
Dianna Province
P. Puntney
Leola Quesenberry
Gerg Quigley
Tom Quinn
Don Rad
John Rada
Hugh Radkins
Hans Radtke
Dayle Rainwater
Clint A. Rand
Ernest Rathbun
Don Rathbun
George M. Rauch
Kathryn Rawls
Dell Raybould
Tina M. Rea
Lynn Reddekopp
Harriet L. Reece
Juanita Reece
Gordon Reed
Ed Reed
Ryan Reese
Tim Reisenauer
Susan Reneau
Dale Renfrow
Kevin Renfrow
Ethel Renfrow
Herman Renfrow
Nat Reynolds
Delbert Reynolds
Dean Rhine
Tim Rich
Jack Richards
Peter Richards
Bill T. Richards
Floyd Richmond
Marshall Richmond
Michael & Nicki Riddle
Bob Riddle
Tom Riel
Louis Riley
Brad Ring
Garry B. Ringold
Joseph R. Rippee
Jim & Janet Ritmann
Crilly R. Ritz
Richard Rivers
John H. Roberts
Mike Roberts
Dale Robertson
Chuck Robinson
Gordon Rogers
Karen Rohn
Robert G. Rollins
Jeff Romane
James Romine
Maurice P. Ronan
JD Ronnberg
Dave Roselip
Tom E. Rosenau
John Roskelley
Leonard H. Ross
David Ruark
Gordon Rubenthaler
Ron Ruddell
Donald Rude
Eugene Rude and Family
Carl Rumd
Lou Runje
Chris Runyard
Greg Rupert
Glenn and Gweneth Russcher
James Russell
Tracee Rybicki
F. Dave Rydalch
LaVonne Ryken
Val Sabo
Eleen Salenik
Tomas O. Salinas
Joy Sampson
Mitch Sanchotena
Charles Sandall
Marshall Sanders
Sean Sanders
Robert Sanders
Justin Sandlin
Robert Sandquist
Kenneth Sandquist
Edwin J. Sandvick
Stu Saslow
James G. Saunders
Kerry Saurey
John Saven
Rick Sawyer

Rod Scarpella
Chris Schaefer
Sam Schainhorst
Dick Schalich
Mark Schaller
Earl Schenck
Raymond A. Schlader
Alvin Schmidt
Lonnie & Nora Schneider
Albert Schoepflin
Raedean Scholfield
Bert Scholz
Leroy Schoot
J.W. Schroeder
Carroll A. Schultheis
J. Leigh Schultheis
Arthur J. Schultheis
Gale A. Schultz
Doug Schuster
Larry Schwab
Jim Schwarting
R. Schwartz
Ernest A. Schwarz
Robert Schweiger
Walter Schweiger
Don Schwerin
Don Scoles
Anthony Scott
Gary Scrimsher
Paul Scroggie
Chris Scuelder
Bud Seabrooke
William W. Searcy
Scott Seegmiller
Jerry Sehlke
Greg Selby
Mike Selivanoff
Norm Semanko
Maynard O. Serbovsek
Rod Seroggin
Robert L. Shantie
Jim Shearer
Tom Shelton
David Shepherd
Patty Sherlock
Marty & Joyce Sherman
Ray Sherwood
Fred U. Shill
Ray C. Short
Allen Short
Tony Sijohn
R. Simmons
Julie Simpson
Floyd Simpson
Phyllis Simpson
Scott Sir
Howard D. Skelton
Larry Slatter
Carole Slaybaugh
Jerry Sloot
Roger Small
Bob Smeltz
Neal Smick
Bert E. Smith
Clinton R. Smith
Bonita Smith
Dan Smith
Robert Smith
Thomas Smith
Dean Smith
Robert Smith
Harvey E. Smith
Richard Smith
Dan Smith
Zane Smith
Glenn Smith
Emily Smith
Jo Snyder
Rich Snyder
Lester Snyder
Jerry Snyder
James Snyder
Abbie Socha
Shirley Sonnichsen
Larry Sooggin
Paul Sorensen
Sandra Souders
Phil Southwick
Steven Spedden
Bertle G. Spence
Alexander R. Spence
Bertle Spence
Clint & Lori Spencer
Robert Sperse
Ruth Spetter
Kyle Splattstoesser
Eugene C. Spray
Carol Springer
Dick Springer
Jack Sprouse
Kenneth J. St Mary
Jim St. Hiloire
Abby St. Lawrence
Marilyn Stamps
Gayle Stantin
Catherine Stapp
Fred Starnes
Jim Startin
Dave Statler
Leroy Steigers
M. Steiner
Max Steward
Johnny G. Stewart
Leman L. Stewart
Al Stifanick
William C. Stillman
Earl Stillman
John Stockman
John Stockton
Vernon Storey
Douglas W. Stout
William J. Strain
Dean Strawn
Jeremy Streufert
Joe Strohmgie
Dave Strong
Dale Stuart
Von R. Studer
Dick Stueckle
Lloyd Stuess
Jim Stutman
Carol Sullivan
Syd Sullivan
Jim Svoboda
Austin Swanson
Greg Swenson
Earl Swift
John Tait
Brian Tank
Tia Tauscher
Henry W. Teal, Sr.
Penny Tee
Brad Telin
Hank Tessitore
Michelle Texley
Dave Thomas
Pete Thomason
Bill Thompson
George Thompson
Scot Thomson
Hazel Thonney
S. J. Tidwell
James F. Titus
Carla Tolliver
Lynn Tominasa
Arne O. Torget
Tara Totten
Richard Towne
John Townsley
Gina Trafton
Hugh Travaille
Willard Treece
David Trent
Kevin L. Tressler
Mark A. Truitt
Kelly Tubbs
Jim Tucker
Ken Tupper

Diane Turnbow
Scott Turner
Rick Turner
A. Rudder Turner, Jr.
Sam Tyler
Laurie M. Tysdal
Alex Uber
Rich Uberuaga
Franky Uhling
John and Kathy Umbarger
Gary R. Underhill
Leonard Van Buren
Elmer Van Cleave
Bill Van Cleave
Steve Van Dyke
Larry VanBuren
Greg Vance
Dick Vandenburg
Ed M. Vanderveer
Val Vanderwall
Jerry VanHollenbeke
Amy Vanhoover
A. M. Vannoy
William VanVogt
Claudia Vetesy
William J. Viers
Ron Vigil
Brett Villaume
Jason Virgil
Eve Vogel
Clara Voss
Mark Voss
Charlene Vullo
Ron Wachter
Joseph Wagner
George W. Walker
Mike Wallace
Richard H. Walser
Philip R. Wandschneider
William I. Ward
Dick Ward
Terry W. Ward
Tom Warden
James A. Warren
Bob Warren
Earl Warren
Glenn Warren
Betty Wartluft
Rick J. Wasem
Linda Wear
Jay Webber
Bill Weber
Edward G. Weber
Fred Weber
Rick Weholt
Lee Wehrli
Rolano Weinlandl
Ken Weiss
Steve Weiss
Lori Weller
Gordon Wells
A. John Wells
LaVell Welp
Lilah Wentela
James R. Westacott
John Westgate
Dave Whitacre
Harold F. White
Pete White
Wayne M. White
John White
Patrick Whitehill
Larry Whitisitt
Richard R. Whitney
Ron Wierenga
Les Wigen
Don Wilkins
Kathy Williams
Barbara C. Williams
Greg Williams
Neil R. Williams
Richard D. Williams
Richard Williams
Mark Williams
Wesley Wilsey
Fred Wilsey
Joel J. Wilson
William H. Wilson
Nancy Wilson
Stan Wilson
Mark Wilson
Curt Wilson
Helen Wilson
Bob Wilson
Ernis Wilson
Truman Wingfield
Ann Winkler
Richard Wiret
Ron Wise
Steve Wise
Wynn Wise
C. Lynn Wise
Desmond Witt
Daniel G. Wittman
Ben J. Wolf
Clifford Wolf
Keith Wolf
Dan Wolf
Walter Wood
Richard Wood
Gene Woodruff
Paul Woods
Nolan Woods
Scott Woolley
Brian Worden
Eunice Worden
Byrdeen Worley
Sam Worrell
Rich Worthington
Harry Wrangham
Marioue Wright
Allison Wright
Chris Wright
Kenneth L. Wulff
Jerry Wyatt
Ron Wynete
Jack A. Yale
Bill Yallup Jr.
Keith Yamane
Robert Yearout
Terry Yearout
Carl Younce
Margaret J. Young
James Young
Andrew G. Zenner
Donald Ziemer
Greg Zilker
Dave Zinecker